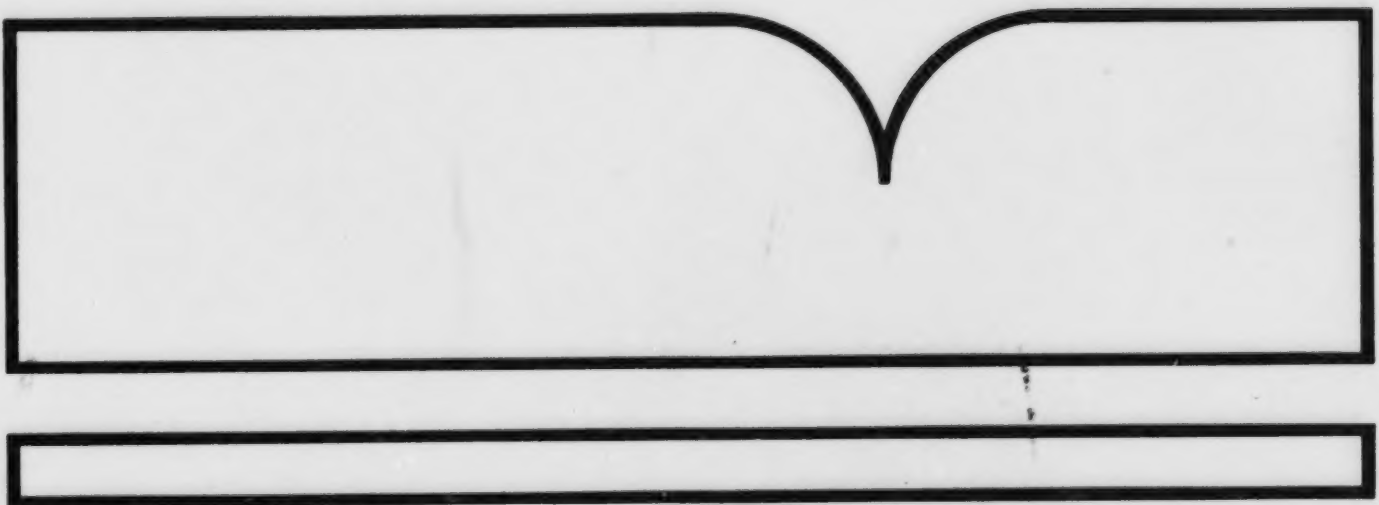


Allocating Chlorofluorocarbon Permits
Who Gains, Who Loses, and What Is the Cost

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Chlorofluorocarbons are suspected of contributing to the depletion of stratospheric ozone. The U.S. EPA sought information on a number of different regulatory options, including the implementation of a marketable permit system in conjunction with a production cap on the manufacture of chlorofluorocarbons at 1980 levels. This report analyzes the implications of various permit distribution systems. It discusses who gains and who loses and what transfers of wealth may occur when permits are allocated or auctioned to manufacturers, first-line purchases, and final users and consumers. The report discusses problems that may arise under the various distribution methods. Each method has its strengths and weaknesses.					
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July 1981

Prepared for the
U.S. Environmental Protection Agency

DISCLAIMER

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PREFACE

This report compares alternative policies for distributing marketable permits under a quota system limiting chlorofluorocarbon (CFC) production in the United States. The principal dimensions of policy comparison are the administrative costs, the effects on resource allocation (costs to the economy as a whole), and the effects on the distribution of wealth (the degree to which the permit policies compensate the losers from CFC regulation). This analysis is intended to assist the U.S. Environmental Protection Agency in choosing among alternative ways to implement CFC regulation.

This research was supported under EPA Contract 68-01-6236. It contributes to a growing body of EPA-sponsored Rand research on CFC regulation. Earlier studies examined the choice between mandatory control and economic incentives as strategies for CFC regulation, and detailed the specific outcomes of an economic incentive strategy that would restrict future U.S. annual CFC production to the 1980 level.

Other Rand publications concerning CFC regulation include:

- o A. R. Palmer et al., Economic Implications of Regulating Chlorofluorocarbon Emissions from Nonaerosol Applications, R-2524-EPA, June 1980.
- o W. E. Mooz and T. H. Quinn, Flexible Urethane Foams and Chlorofluorocarbon Emissions, N-1472-EPA, June 1980.
- o K. A. Wolf, Regulating Chlorofluorocarbon Emissions: Effects on Chemical Production, N-1483-EPA, August 1980.

distributed; therefore, decisions on where and how to reduce CFC use and emissions are decentralized--they are made by private firms and individuals. The various marketable permits systems we examine differ in the method employed to distribute permits to the private sector initially. Under a permit auction, permits are initially sold to the highest bidders. Under the allocation policies, permits are allocated at a zero price to firms that produce, distribute, or use CFCs, on the basis of a variety of specific allocation formulas.

Although these policies differ only in their permit distribution method, they perform very differently on the basis of several evaluative criteria. These criteria include a policy's distributive effects, its administrative complexity and costs, and its effects on the efficiency of resource use in the private sector.

The CFC permit auction serves as a benchmark, against which the effects of alternative allocation policies are measured. An auction lies at or near the low end of the administrative cost range for permit policies. The auction outcomes also identify the consequences of any permit policy that promotes private sector efficiency in resource use: It minimizes regulation's real resource costs for the whole economy, but also results in increased production costs to CFC-user firms, higher prices for customers, and some reductions in final product output that may imply worker unemployment and even plant closures.

The auction's distinguishing feature is the generation of large government revenues, accumulating to over \$2 billion from 1981 through 1990.(2) These auction proceeds represent a substantial wealth transfer

(2) Unless otherwise noted, financial data are expressed in 1976 dollars and cumulative estimates are discounted to 1981 at 11 percent.

- o A. R. Palmer and T. H. Quinn, Economic Impact Assessment of a Chlorofluorocarbon Production Cap, N-1656-EPA, February 1981.

For a summary of findings from the earlier research, see:

- o A. R. Palmer et al., Economic Implications of Regulating Nonaerosol Chlorofluorocarbon Emissions: An Executive Briefing, R-2575-EPA, July 1980.

SUMMARY

The use of economic incentives, such as pollution taxes or marketable permits, for environmental control has attracted increasing attention in recent years. Relative to mandatory controls or other forms of direct regulation, these market-oriented policies can lower the cost of achieving environmental objectives for the economy as a whole. But economic incentives pose some major implementation issues. Chief among these are the distributive effects of these policies: Depending upon how the policy is implemented, serious losses can be imposed on specific groups in the economy--namely, the workers, customers, and owners of regulated firms. This trade-off between the aggregate costs of regulation and how the cost burden is distributed poses a fundamental policy challenge, which is the focus of this research: Is it possible to design regulatory strategies that retain the lower aggregate costs of economic incentives without imposing such heavy losses on certain groups in the economy?

This report examines alternative ways to implement marketable permits in the case of chlorofluorocarbon (CFC) regulations currently under consideration by the U.S. Environmental Protection Agency.[1] Under all the policies considered here, growth in aggregate domestic CFC use beyond the 1980 level is prohibited, and permits are issued to authorize CFC use under the quota. The permits are completely transferable within a permit market (or "aftermarket") once they have been initially

[1] CFCs are suspected of depleting the earth's protective layer of stratospheric ozone.

away from the consumers, workers, and owners of CFC-user firms to taxpayers. However, these proceeds also represent wealth that is available for distribution to regulation's potential losers under the permit allocation policies.

All of the allocation policies stop the auction's flow of wealth to the U.S. Treasury, but differ substantially in other ways depending upon who receives permits and the nature of the allocation formula. Ultimately, we find that it is much easier to prevent the inflow of payments to the treasury than to compensate regulatory losses accurately.

Neutral allocation formulas give recipient firms lump-sum permit grants. We examine the wealth benefits to firms of several neutral formulas based on historical or projected CFC use or sales by the CFC producers, CFC-using firms, and, in one case, CFC distributors. These allocations differ in their administrative costs--with formulas involving the numerous CFC-using firms being most costly. Like the permit auction, neutral allocations lead to efficient private sector resource use; in contrast with the permit auction, the wealth represented by the market value of permits accrues to the owners of recipient firms rather than to taxpayers in general. Because lump-sum permit grants provide no incentives for permit recipients to pass on benefits, the neutral policies do nothing to ameliorate the regulatory losses of consumers or workers.

We also estimate outcomes for a nonneutral allocation formula that initially allocates permits to CFC-using firms on the basis of their share of total final product output. The final product formula distributes the wealth that would otherwise go to the federal government under

an auction in the form of a per-unit subsidy to production. This formula relieves the majority of the regulatory losses suffered by workers, consumers, and others who are not benefited by a neutral policy. This policy relies on market forces to target benefits on those parties that would otherwise be most harmed by CFC regulation. More than any other policy, the final product formula achieves the CFC quota without serious harm to any of the participants in CFC-related markets.

But these distributive effects are not without a significant cost. The final product formula is administratively the most complex and costly policy considered in this report, and it achieves its distributive goals by generating inefficiencies in the permit market and the final product markets. For example, the policy would raise the real resource cost of regulation by 16 percent--nearly \$6 million--in 1985. Even with these added resource costs, the final product formula is far more efficient than mandatory controls. And the added administrative costs are not large when compared to the regulatory losses they prevent for the policy's beneficiaries. Nevertheless, under the final product formula, the nation's economic pie is smaller than under any of the other marketable permits policies.

In short, the policy choice among alternative forms of implementing CFC marketable permits is not an easy one. Invariably, policies that are relatively attractive on the basis of some evaluative criteria are relatively unattractive on the basis of other criteria. As a result, we do not recommend any policy as superior to the alternatives. That choice depends upon the importance attached to the various dimensions of policy comparison--a judgment we leave to policymakers.

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Three Rand colleagues made valuable technical contributions to our work. Charles Phelps, Director of the Rand Program on Regulatory Policies and Institutions, was especially supportive of our interest in the distributive consequences of regulation and provided guidance throughout the research. James Dertouzos and Frank Camm made detailed and highly useful comments on an earlier draft of this report. In particular, Frank Camm contributed substantially to our understanding of the ability of the final production allocation formula to compensate owners of fixed human and physical capital.

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I. INTRODUCTION

Regulation--or, for that matter, deregulation--creates winners and losers. To give a community's citizens cleaner air to breathe, local manufacturers and their customers bear the costs of pollution control. To safeguard a source of food supply and the livelihood of fishermen, industry pays to seal and bury wastes that would otherwise be dumped in waterways. The regulatory intention might be to serve a broad social goal--to create aggregate benefits in excess of aggregate costs. Nevertheless, imposing costs on some members of society so that others might benefit is a virtually inescapable consequence of regulatory action.

In recent years, policymakers have taken extraordinary steps to counter the distributive consequences of policy. They have imposed special taxes on companies that would benefit from price decontrol. And they have paid compensation to workers who lose their jobs as a result of regulatory action. Sometimes, the objective is to make regulatory change more acceptable to voters. Sometimes, the motive is a more general concept of fair play--a desire to reimburse members of society who, through no fault of their own, are caught in the nexus of changing social goals. But for whatever reason, the emerging pattern of policy decisionmaking is one in which distributive issues share the spotlight with the question of whether aggregate benefits exceed aggregate costs.

The policy relevance of distributive issues is nowhere better exemplified than in the case of chlorofluorocarbon (CFC) regulations currently under consideration by the U.S. Environmental Protection

Agency.[1] Previous CFC policy research (Palmer et al., 1980a) showed that a choice between regulatory strategies having equal aggregate benefits implies a trade-off between the aggregate costs of regulation and the way the cost burden is distributed. Mandatory controls[2] are the less efficient choice, imposing higher costs on the U.S. economy as a whole. But an alternative policy that sets a quota on CFCs and sells permits to use them--an economic incentives policy--imposes a far heavier cost burden on the CFC-using industries and their customers.[3]

The government's sale of permits under a CFC quota imposes higher costs on user industries because it requires them to pay a premium for all the CFCs they continue to use. The policy allows firms to find the most efficient (cost-saving) set of technologies to limit CFC use. But, relative to mandatory controls, the lower technological costs are far outweighed by the large payments for permits. The permit payments do not increase the policy's aggregate costs because the money is paid into the general treasury where it becomes available for other purposes. But the payments do transfer wealth away from the CFC-using industries and their customers.

But can this transfer of wealth, which may make economic incentives policy appear unattractive according to distributive criteria, be

[1] Several CFC chemicals are emitted into the atmosphere where they may deplete the ozone layer that protects life on earth from harmful ultraviolet radiation. Aerosol applications of CFCs have been banned in the United States. The discussion in the text refers to nonaerosol applications that are as yet unregulated. They include refrigeration devices, cushioning and insulating foams, industrial solvents, and a wide variety of miscellaneous uses.

[2] Rules requiring industry to use specific technologies, such as recovery and recycle, to limit CFC use and emissions.

[3] The same can be said for an economic incentives policy that imposes a tax on CFCs without imposing a quota.

avoided? In general, is it possible to achieve the lower aggregate costs of economic incentives without imposing such heavy burdens on selected industries, their workers, and customers? These are the central questions addressed by this study.

We find that it is far easier to prevent the inflow of payments to the federal treasury than to be sure that the people who bear the costs of regulation are appropriately compensated.[4] Because CFC permits have resale value, the government can confer wealth on private firms or individuals by giving them permits. The government can give CFC permits away to a variety of recipients under a variety of formulas, and thereby eliminate an inflow of funds to the general treasury. But there are relatively few ways to allocate permits that will benefit the firms, workers, and consumers most harmed by CFC regulation.

Compensating the losers from CFC regulation is costly. The necessary permit allocation mechanisms are administratively expensive. And the mechanisms create some market inefficiencies that add to CFC regulation's cost to the economy as a whole. Because the administrative costs are small relative to the value of the CFC permits to be given away,[5] recipient firms should be willing to pay those costs, if ways can be found to shift the costs away from the government.[6] Moreover, the added inefficiency cost of compensation is not large enough to

[4] Even if the transfer payments could be perfectly redistributed, there would still be losses that remained uncompensated. These losses, however, would be attributable solely to the real resource costs of the policy.

[5] This is true given the level of the CFC quota considered in this study. It might not be true for a sufficiently less restrictive quota, because then the magnitude of transfer payments would be less.

[6] Our analysis suggests some ways to shift the costs, but their legal and bureaucratic feasibility is beyond our expertise to judge.

offset the efficiency advantage of economic incentives over mandatory controls. Nevertheless, compensating regulation's losers requires a trade-off in terms of higher administrative and resource costs.

The next five sections of this report examine alternative strategies for administering marketable permits under a CFC quota. In one case, the permits would be sold (auctioned to the highest bidders). In the remaining cases, the permits would be given away (allocated) to different groups of recipients according to different rules (formulas) determining how many permits each recipient would receive. In all cases, private parties are also allowed to buy and sell permits among themselves at market-determined prices.

The allocation policies studied here were selected in a preliminary analytical effort. We identified various groups of potential permit recipients: the CFC producers, distributors, user firms, and workers and customers in user industries. We identified several possible bases for the allocations including (among others) historical and predicted levels of CFC use or production. We recognized that the total allocations could range over any fraction (from zero to one) of the total number of permits to be issued. And we considered alternative "dynamic" properties of the allocations, such as whether new firms entering an industry would be eligible. Although the resulting combinations of features yielded a potentially infinite number of candidate allocation formulas, preliminary analysis suggested they could be grouped according to similarity in administrative cost, distributive effects, and effects on the efficiency of private sector resource use. From this information, we concluded that certain groups of formulas should be examined in

order to portray a wide range of possible policy outcomes, and that certain formulas within the groups should be included because they are particularly interesting to EPA.

To facilitate comparisons among the permit policies, the CFC quota policy is held constant. It restricts the weighted sum of domestic annual sales of CFC-11, -12, -113, and -502 to the 1980 level--341.0 million weighted pounds.[7] The weighting factors, shown in Table 1.1, reflect EPA's preliminary estimates of the environmental hazard posed by the different CFC chemicals. The quota would allow production of the individual CFCs to vary, provided the overall "cap" is maintained. Because the quota is the same for all the permit policies, the environmental benefits are the same and differences in the level and

Table 1.1

CFC WEIGHTING FACTORS

Type of CFC	Weighting Factor (weighted pounds per pound of CFC)
CFC-11	1.00
CFC-12	0.79
CFC-113	0.77
CFC-502	0.19

SOURCES: EPA (1980) and Palmer and Quinn (1981).

[7] The quota under consideration is nearly equivalent to a policy that restricts imports plus domestic production of the listed CFCs to the 1980 level, provided intermediate CFC uses (uses in which CFCs are used to form other chemicals) are exempt. For a discussion of the discrepancies between a production cap and the policy analyzed here, see Palmer and Quinn (1981).

distribution of the regulation's costs can be attributed solely to differences in permit administration.

Section II examines the implications of a policy that auctions (sells) permits under the quota. We discuss administrative issues, such as the choice between auctioning permits just once or repeatedly over time. We explain why the policy results in an efficient use of resources in the private sector (thus minimizing regulation's costs to the private economy as a whole)--and how that efficiency affects real resource costs in user industries, consumer prices, plant closures, and worker unemployment. More generally, this part of the analysis identifies the potential losers (and even a few winners) from an efficient economic incentives policy. Finally, we quantify the flow of transfer payments into the federal treasury resulting from the permit auction.

The permit auction of Sec. II represents a base case for comparison with other ways of introducing permits to the marketplace. Some administrative issues, such as whether and how often to reissue permits, are common to a variety of permit policies. Many permit policies lead to equally efficient resource use, and thus have the same resource cost, consumer price, plant closure, and worker unemployment effects as a permit auction. Moreover, the revenues generated by a permit auction measure the transfer payment wealth available to be redistributed under alternative permit policies. Thus, the permit auction case identifies a basic set of CFC regulatory outcomes with which other permit policies can be compared and contrasted.

Sections III and IV describe permit allocation policies that eliminate the flow of funds into the general treasury and lead to efficient

market outcomes in the private sector, but result in vastly different administrative costs and distributions of wealth. Giving the permits to the CFC producers (Sec. III) is inexpensive to administer but concentrates the wealth transfer receipts in the hands of a very small number of firms. Under the permit allocation rules of Sec. IV, the wealth is distributed widely among owners of CFC-using firms, but at high administrative costs. Though the policies in Secs. III and IV lead to vastly different wealth distributions, neither policy compensates the consumers or workers most harmed by regulation.

By comparison with Sec. IV's results, Sec. V shows how a change in the permit allocation formula can induce the owners of CFC-using firms to pass through some wealth transfers to their workers and customers. The permit allocation in Sec. V most closely targets wealth transfers on the individuals most harmed by CFC regulation, but at considerable administrative cost and some added cost in market inefficiency. Section V also explains why benefiting consumers and workers who lose from CFC regulation requires these additional costs.

While many of the permit allocations we examine would have relatively high administrative costs, the two permit policies with low administrative costs--the permit auction and allocations to producers--have some disadvantages. The auction might be illegal without new legislation, and the producer allocation concentrates the wealth transfers in the hands of a few highly visible firms. Another permit policy, examined in Sec. VI, would spread the wealth among a large number of "first-line buyers"--owners of firms that buy CFCs directly from the producers--while remaining fairly inexpensive to administer.

The first-line buyer allocations result in an efficient use of market resources, and eliminate the flow of transfer payment wealth into the U.S. Treasury. The wealth is instead distributed among a few thousand firms, including CFC producers, certain CFC-using firms in certain user industries, and also a group of firms that stands to lose little if at all from CFC regulation--CFC distributors.

Given the CFC quota policy under consideration, permit policies that are inexpensive to administer do a poor job of compensating the losers from regulation, while permit policies that do a good job of compensating losers are very expensive to administer. But would this pattern of trade-offs apply if the level of the CFC quota were changed? Would alternative permit policies have the same advantages and disadvantages if used in combination with economic incentives in cases other than the CFC case? These are some of the broader policy issues we examine in the final section of this report.

II. BASE CASE FOR POLICY COMPARISON: A CFC PERMIT AUCTION

A permit auction is a useful benchmark for comparing alternative permit policies. The auction is a relatively straightforward mechanism for initially placing CFC marketable permits into the economy. And an analysis of the policy's administrative features identifies several issues that must be addressed by permit allocation policies as well. Most important, a permit auction's economic effects identify some regulatory consequences that permit allocation policies might seek to alter and other consequences that allocation policies might seek to replicate.

The permit auction--and many allocation policies as well--result in an efficient allocation of resources in the private sector. Efficient policies minimize the real resource costs of actions taken by firms and consumers to restrict CFC use to the quota level. But efficiency also requires higher production costs in the CFC-using industries, higher prices for their customers, and some reductions in final product output levels that may imply worker unemployment and even plant closures. In short, a permit auction and other efficient permit policies minimize the quota's cost to the economy as a whole by causing changes in economic conditions in the CFC-using industries.

What makes the permit auction unique is that it generates large revenues to the federal government. Unlike any of the permit allocation policies, the permit auction provides a mechanism whereby wealth is transferred away from the regulated industries and their customers and into the U.S. Treasury. Thus, while the auction minimizes regulation's

costs to the economy as a whole, it maximizes the adverse consequences of the quota for the CFC-related industries.

By examining the outcomes under a permit auction, we can clearly identify the losers (as well as some gainers) from a CFC quota. And we can quantify the wealth transfers to the federal government that might otherwise be made available to compensate regulation's losers.

ADMINISTRATIVE ISSUES

Many basic permit design and administrative issues must be resolved, regardless of whether an auction or permit allocation is used as the initial distribution mechanism. For example: How should a permit be defined, and what rights and responsibilities do permit holders have? How should an "aftermarket" mechanism be organized to facilitate mutually beneficial exchange of permits within the private sector? Here we address those basic design issues, followed by some administrative questions specific to a permit auction.

Permit Design Issues

One essential feature of all the policies considered in this study is that permits are fully, legally transferable. A permit holder may sell his permits to anyone at freely determined market prices. This is necessary to assure that permits flow to their highest valued uses, as dictated by market forces.

A second essential feature is that a permit entitles its holder to purchase and use (or sell) one weighted pound of any CFC.[1] This

[1] Given the weights reported in Table 1.1, one permit can be used to acquire 1.00 pound of CFC-11, 1.27 pounds of CFC-12, 1.30 pounds of CFC-113, or 5.26 pounds of CFC-502. By implication, the number of permits available to be auctioned or allocated under the 1980 CFC quota would be 341.0 million.

assures that at any time there is a single equilibrium market value of a permit (whether in a permit auction or in subsequent aftermarket transactions) determined jointly by the demand and supply conditions for the various regulated CFCs. And, because the permit applies to a weighted pound, the permit price raises the per-pound prices of heavily weighted CFCs more than those of less heavily weighted (and thus presumably less environmentally hazardous) CFCs.

A third feature common to all the policies examined here is that a permit authorizes the purchase of just one weighted pound in any given year; the authorization cannot be held over for a future year. This rule probably does not allow the quota policy to achieve the lowest resource costs of which it is capable.[2] On the other hand, the rule does guarantee stable annual aggregate production of CFCs under the quota, thereby facilitating its enforcement. Whether the rule is desirable in practice depends on the precise relationship between its effects on resource and enforcement costs, a matter not examined in this report. The rule is established here for analytical convenience. By holding this rule constant, we do not contaminate comparisons among alternative permit policies by variations in the underlying quota policy.

Aside from the three permit features that are held constant throughout this study, several features of permit design are allowed to vary.

[2] Analysis shows that the same decade-long restriction on CFCs could be achieved at lower resource costs by allowing larger cut-backs in early years and smaller ones in later years. (See Palmer et al., 1980a.) This may be achieved to some degree even if annual sales are held constant because firms can inventory CFCs. However, a policy that allows permit holdovers would probably be more efficient because permits are cheaper to inventory than are drums filled with chemicals.

Perpetual versus Annual Rights. Although this analysis assumes a strict annual quota, the question remains whether permits should be auctioned (or allocated) periodically or on a "once and for all" basis. Under a once and for all mechanism, each permit would represent a perpetuity, entitling the holder to use one weighted pound each year forever. Alternatively, a permit could represent an annual right, good only during the year for which it was issued; in this case, permits would be reissued every year.

Many permit policies allow a choice between annual rights and perpetuities. An auction is consistent with either type of permit. Allocation policies that do not vary a recipient's allocations over time can use either perpetuities or annual rights.[3] However, a few of the allocation policies examined in this report require annual rights so that permit allocations can vary from one year to the next.

If a firm obtains a perpetuity, it can sell it outright in the aftermarket or "lease out" the permit for a year or more. Throughout our analysis, a firm that "buys a lease" for a year obtains the same rights as it would from buying an annual right.[4]

[3] To make annual rights equivalent to a perpetuity policy, recipients must continue receiving annual allocations even if they go out of business.

[4] The verbs "to lease" and "to rent" are expositionally inconvenient because they do not clearly discriminate between the act of releasing rights and the act of obtaining rights. We use the phrases "buy a lease" and "sell a lease" in this report for this reason. In addition, our terms convey the notion that there are no restrictions on the use of the lease. A landlord might prohibit his tenant from modifying a rented structure. In our analysis, the seller of a lease cannot restrict the purchaser's use of the lease. The only condition on the lease is that the rights to the use of the perpetuity revert back to its seller when the lease term expires.

The market value of a perpetuity equals the expected present value of an infinite stream of annual permits. Because actual permit values in later years might vary from expectations, buyers of perpetuities might find the price they paid was a bit too high or too low. In short, there is a risk associated with buying perpetuities that might be reflected in their price.[5] Nevertheless, in each subsequent year, the use of a perpetuity could be leased out for the same price at which an annual permit would sell in that year. Therefore, perpetuities and annual rights would lead to the same use of resources and other private sector outcomes estimated below.

If perpetuities are issued, permit holders would hold an explicit right to acquire a specified amount of CFCs each year indefinitely. A pertinent legal issue is whether the regulatory agency could rescind such explicit rights, if, for example, a more stringent cap were considered in the future.[6] In contrast, if a new vintage of permits were issued each year, it might be easier to reduce subsequently the overall

[5] In accounting, a perpetuity can be recorded as an intangible asset, while the promise of a future allocation of annual rights cannot be. For this reason, a stream of annual rights might be less highly valued by a firm.

[6] The regulatory agency might, of course, buy back permits at current market prices. However, such an action would require a large expenditure of public funds. Suppose, for example, that in 1985 the EPA sought to buy back only 10 percent of the outstanding 341 million perpetuities. While we have not estimated the annual value of permits beyond 1990, if the lease value of permits stabilizes at the 1990 level (\$2.80 per year), the price of a perpetuity in 1985 could be as high as \$20.64 (expressed in constant 1976 dollars). Thus, this seemingly modest buy-back would require as much as \$704 million. Even if this perpetuity price is a substantial overestimate, it is unclear how such an expenditure would be financed, since the auction proceeds revert to the general treasury and not to the EPA.

CFC quota. Consequently, industry probably faces more uncertainty about the future level of the quota if annual rights are used.

The choice between perpetuities and annual permits involves a trade-off between auction or allocation costs and the costs of transactions in the permit aftermarket. With perpetuities, an auction or allocation need be conducted only once, so the government's administrative cost and firms' participation costs are low. But as market conditions change over time, the perpetuities must be bought and sold (or leased) to allow an efficient allocation of CFC production and use. These transactions impose costs on the private sector. In comparison with perpetuities, annual rights generate repeated auction or allocation costs, but relatively few aftermarket transactions.

Transaction Mechanisms. Regardless of whether permits are perpetuities or annual rights, a marketable permits system requires a well-functioning aftermarket mechanism for permit transactions.

One option is to issue paper certificates that might physically resemble paper currency or ration coupons. The certificates could be exchanged with the CFC manufacturers in return for CFCs or with another party (who would also ultimately redeem them with the manufacturers) in return for cash.

An alternative identified by EPA is to use permit "checking" accounts. In this case, the EPA would establish and record changes in permit checking balances for permit holders. Rather than using paper permits, eligible parties would transfer the rights to acquire CFCs by writing permit checks. These transactions would be recorded and account balances transferred by EPA, just as commercial banks record transactions of demand deposits. Under an initial permit auction, firms in the

CFC-related industries would, in effect, submit bids for an initial checking account balance.

As with the choice between perpetuities and annual permits, the choice between certificates and checking accounts affects certain costs and who pays them. Although paper permit certificates presumably could be printed in different denominations, the checking account option allows greater denominational flexibility and large transactions would not require the physical transfer of a large volume of paper permits. Moreover, the agency would, in effect, provide a central clearing-house for permit transactions. Thus, the checking account option probably lowers aftermarket transactions costs. On the other hand, a significant advantage of issuing certificates is that continuous government monitoring of accounts is not required.[7] Thus, the choice between certificates and checking accounts involves a trade-off between transactions costs in the private sector and the government's monitoring costs.

The Auction Mechanism

Public auctions are not an unfamiliar tool to the government. In many instances--for example, off-shore oil leases--auctions have been used by the government to issue property rights to the private sector. A CFC permit auction might follow many of the basic procedures developed in previous auction experiences. CFC permits should be relatively easy to auction, because they are homogeneous. In contrast, leases for different off-shore parcels may dramatically differ in value.

[7] Both certificates and checking accounts require enforcement against forgery and fraud. Judging which system is best on enforcement grounds is beyond the scope of this study.

There appears to be little reason to restrict participation in the auction.[8] Obvious candidates for participation are the CFC producers, distributors, and CFC-using firms. In deciding whether to participate, eligible firms will weigh the costs of directly participating in the auction against the transactions costs for obtaining permits in the aftermarket; some firms that are eligible might well decide not to participate in the auction.[9] If the auctioning agency restricts participation, it might reduce its administrative costs somewhat, but it might impose higher aftermarket transactions costs on private industry, and even run the risk of encouraging collusion among a small number of permit bidders. In the end, a properly functioning permit aftermarket will assure that permits flow to their highest valued uses, regardless of who is allowed to participate in the auction.

OUTCOMES UNDER A PERMIT AUCTION

Palmer and Quinn (1981) analyzed a permit auction's economic effects in detail. Here we summarize those findings, with a view toward identifying groups in the CFC-related industries whose regulatory burden might be alleviated by an allocation policy.

[8] In principle, even conservation groups might be allowed to participate; if so, they could buy permits to prevent their redemption and thus control CFC emissions even more than the quota does. Note that precluding their participation in an auction will not prevent conservation groups from achieving this goal, because they can still buy permits in the aftermarket. In any case, this issue appears to have little practical significance because no organized conservation interest group has expressed any interest in participating in the permit market.

[9] If, as we suspect, the costs of participating in the auction do not vary much with the number of permits a firm bids for, then major participants in the CFC market will be more likely to participate than minor ones. Consequently, the most likely auction participants are the producers, large distributors, and large user firms.

The analysis concentrates first on the economic impacts in the private sector that result from the auction's efficiency characteristics--outcomes that an auction shares with other efficient policies. We then examine the government revenues generated by the auction, estimating the size of this flow of wealth that is, in effect, used by the allocation policies to compensate for regulatory losses.

CFC and Permit Prices

A CFC quota increases CFC prices. Table 2.1 shows the effect on CFC prices when a permit auction is employed to achieve the quota level. The rapid projected rise in CFC prices reflects expected growth in CFC demand in nearly all nonaerosol applications.

The permit prices indicate the expected auction prices that would be paid for annual rights or, alternatively, the price that would be paid to lease a perpetuity during the indicated year. We would also expect exchanges in the permit aftermarket to occur at these prices.

Resource Costs

Under an efficient policy, the prices that firms must pay to acquire permits will reflect accurately the economic value of permits in alternative uses. This value is determined by the resource costs that firms (or their customers) would incur to reduce their CFC use. A firm will only reduce its CFC use if the associated resource cost is less than the prevailing permit price. Thus, permits will be used by those that value them the most; and CFC use reductions will be undertaken by those who can do so at the lowest cost. In short, an efficient policy

Table 2.1

ANNUAL EQUILIBRIUM CFC AND PERMIT PRICES UNDER
A PERMIT AUCTION: 1981 TO 1990

Year	^a Total User Price per CFC Pound (In \$ 1976)				^c Permit Price
	CFC-11	CFC-12	CFC-113	CFC-502	
^b					
1980	0.34	0.41	0.60	1.11	0.00
1981	0.43	0.48	0.67	1.13	0.09
1982	0.62	0.63	0.83	1.16	0.28
1983	0.79	0.77	0.99	1.20	0.45
1984	1.02	0.95	1.19	1.24	0.68
1985	1.28	1.15	1.40	1.29	0.94
1986	1.50	1.33	1.58	1.33	1.16
1987	1.69	1.48	1.74	1.37	1.35
1988	1.96	1.69	1.97	1.42	1.62
1989	2.27	1.93	2.23	1.48	1.93
1990	3.14	2.62	2.95	1.64	2.80

SOURCE: Palmer and Quinn (1981).

^a

Total user price equals the CFC sales price paid to the manufacturer plus amounts paid for permits.

^b

Indicates the base CFC sales price, assumed constant over time in real terms for each CFC, except CFC-113. For CFC-113, the sale price varies due to economies of scale. See Palmer and Quinn (1981, pp. 65-67).

^c

Indicates expected auction price for annual permits or, alternatively, the lease value of a perpetual right in the indicated year. A permit entitles the holder to use one weighted pound of any CFC.

minimizes the costs of actions taken by firms and consumers to restrict CFC use to the regulated level.

Because a permit auction is an efficient policy, the resource costs it generates are the lowest achievable under a CFC quota. These resource costs are presented in Table 2.2. For most industries, these

Table 2.2
PROJECTED RESOURCE COSTS BY USER CATEGORY UNDER A PERMIT AUCTION: 1981 TO 1990
(In \$ million 1976)

User Category	Resource Costs											Cumulative ^a
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1990	
Flexible foam	0.6	1.4	3.5	5.4	10.4	17.9	27.1	29.1	31.5	37.3	82.9	
Solvents	0.1	1.6	4.1	8.3	12.3	16.6	21.6	29.6	39.0	56.7	93.7	
Rigid foam												
TPS	0.0 ^c	0.2	0.7	1.7	2.7	3.5	4.8	10.9	18.2	19.0	29.1	
Insulation	0.0	0.0 ^c	0.1	0.2	0.5	1.0	1.8	3.2	5.5	13.9	11.5	
Other	0.0 ^c	0.1	0.3	0.9	1.9	3.4	5.0	7.8	10.9	14.1	20.9	
Mobile air conditioning												
Manufacturing	0.0 ^c	0.1	0.4	1.3	2.6	4.2	5.9	8.6	11.3	14.1	23.3	
Servicing	0.0 ^c	0.1	0.1	0.3	0.6	1.0	1.4	2.1	3.3	3.7	6.0	
Retail food refrigeration	0.1	0.7	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	4.8	
Chillers	--	--	--	--	--	--	--	--	--	--	--	
Home refrigeration	--	--	--	--	--	--	--	--	--	--	--	
Miscellaneous	0.0 ^c	0.1	0.4	1.4	3.0	5.4	8.0	12.5	17.6	23.1	33.6	
Total ^b	0.8	4.1	10.2	20.2	34.7	53.7	76.4	104.6	138.0	182.7	304.9	

SOURCE: Palmer and Quinn (1981).

^aSum of annual resource costs, discounted to 1981 at 11 percent.

^bDetail may not sum to totals due to rounding.

^cResource costs positive, but less than 0.1 after rounding.

resource costs represent expenditures by regulated firms on technical responses to reduce CFC use--for example, the acquisition of recovery and recycle equipment or the use of more expensive non-CFC chemicals. However, some of the resource costs in the flexible foam user category and all the resource costs in the thermoformed polystyrene (TPS) and insulation categories reflect the costs of actions taken by consumers to reduce CFC use--for example, switching from CFC-blown foam insulation to alternative insulation materials, because of higher foam prices.[10] As Table 2.2 indicates, cumulative resource costs from now through 1990 under the permit auction are about \$305 million (in 1976 dollars, discounted to 1981).[11]

Production Costs and Returns to Capital

For firms that use CFCs, higher CFC prices mean increased production costs, reflecting both the higher prices firms must pay for the CFCs they continue to use and the costs of technologies employed to reduce CFC use. While final product prices will rise as a consequence (see below), the increase may not be sufficient in the short run to offset the firms' higher costs. The result: The policy devalues fixed

[10] For TPS foams, this represents a revised interpretation of the CFC demand schedule analyzed in Palmer and Quinn (1981). The purpose and significance of the reinterpretation are discussed in Sec. V of this report.

[11] Unless otherwise indicated, all cost and price data in this report are stated in 1976 dollars to facilitate comparisons with results reported in Palmer and Quinn (1981) and Palmer et al. (1980a). If specified in 1980 dollars, the estimates would be approximately 1.5 times as large as shown. Note that our earlier reports discounted cumulative cost estimates to 1980, instead of 1981. To make the cumulative estimates presented here comparable to those in our earlier reports, divide by 1.11.

human and physical capital investments in the CFC-related industries. In an industry with stable demand, some owners will eventually retire their capital and exit the industry. In a growing industry, entry will be forestalled until rising prices return existing firms to competitive rates of return on capital.[12]

Consumer Prices

For consumers, higher CFC prices mean increased consumer prices. No segment of the CFC-related industries will escape higher final product prices, although in some cases the impact on the goods consumers actually buy will be relatively small. In the short run, the increased costs in the CFC-user industries will not be fully reflected in higher prices, because firms will earn subnormal returns for a time. However, in the long run, the returns to capital in these industries must return to competitive levels. As a result, cost increases will eventually be fully reflected in higher consumer prices.

To cite only a few examples, we estimate that by 1990 the price of home refrigerators will increase by over \$7 and home freezers by nearly \$9, relative to the absence of regulation. Purchasers of mobile air conditioners will be paying over \$6 more per unit. And retail food stores (and ultimately their customers) will pay more for their refrigeration systems, as much as \$3,000 more per store for large supermarkets. These price increases represent exceedingly small percentage

[12] This statement assumes rates of return were competitive prior to regulation, which would be true in perfectly competitive industries. Firms earning a higher than competitive rate of return prior to regulation would still suffer a regulatory loss by the same reasoning presented in the text.

increases in final product prices. Nevertheless, they are still large enough to cause annual wealth transfers in 1990 of over \$80 million away from home refrigeration consumers and over \$70 million away from consumers of mobile air conditioners.

In some cases, even the percentage increase in final product prices will be significant. This is most likely for the CFC-blown plastic foams. By 1990, foam prices could increase by 41 percent for some flexible urethane foam products, by 38 percent for extruded polystyrene board (Styrofoam) insulation, and by nearly 60 percent for rigid urethane insulation. For TPS foam products, prices by mid-decade will increase by at least 10 to 12 percent.

Worker Layoffs and Plant Closures

When consumers can obtain good substitutes for CFC-made products, they can avoid much of the losses associated with higher prices. However, product substitution is a mixed blessing. Reductions in CFC-product sales means that workers may be laid off in the CFC-related industries.[13] In effect, losses suffered by CFC-related workers replace losses otherwise suffered by consumers.

In extreme cases, product market contraction can cause plant closures, resulting in the unemployment of the entire work force of some plants. The greatest risk of plant closures appears to be in the flexible foam and the TPS foam industries. Especially in the latter industry, it appears likely that significant numbers of consumers will turn

[13] Of course, employment will increase in the industries making the substitute products.

to non-CFC final products.[14] While estimates of the worker impacts of a CFC auction are highly uncertain given available data, we estimate the producers of CFC-blown polystyrene sheet alone employ nearly 5,000 workers, and a significant fraction could eventually lose their jobs under CFC regulation.

Generally, however, we do not expect worker unemployment or plant closures to be widespread. Because CFCs almost universally account for only a small fraction of production costs, it takes a large increase in CFC prices to cause an appreciable increase in production costs and final product prices. Initially, the effects of an auction (or any other policy) on CFC prices are relatively small. As Table 2.1 indicates, even as late as the third policy year, the permit price is only \$0.45 per weighted pound. By the time the permit price is sufficiently high to have a large impact on any product price, most of the CFC-related industries will have experienced significant growth. Consequently, with the possible exceptions noted above, CFC regulation will primarily prevent increases in the employment levels and number of plants in these industries, rather than causing the layoff of currently employed workers or capital.

Effects on the CFC Manufacturers

Regulation's impact on the CFC manufacturers is difficult to quantify. The CFC manufacturers have made large investments in their

[14] Plant closures can also occur if regulation significantly increases the optimal scale of production, in which case fewer plants would produce a given level of industry output. In both the flexible foam and TPS foam industries, there is also evidence that plants may, on average, become larger.

production facilities, at least partly in anticipation of market growth. An overall "freeze" on CFC markets, particularly only a few years after the ban on CFC aerosol applications, could devalue those investments. Some plant capacity will likely remain idle because of the CFC quota, but the value of the implied losses to manufacturers is unknown.[15]

Some observers, noting that there are only five CFC producers, have suggested that collusion could play a role in determining producers' gains or losses from a CFC quota. If regulation made the market less collusive, the CFC producers would lose some of the abnormal profits available from collusion; alternatively, if regulation made the market more collusive, the CFC producers would gain abnormal profits.

There is no evidence to suggest that the producers currently collude to restrict CFC supplies and charge artificially high prices--and regulation should make collusion even more difficult than it is now. Although CFC imports have been few historically, the existence of potential foreign suppliers makes current domestic collusion unlikely. Moreover, collusive arrangements rarely survive major market contractions, such as the CFC industry experienced in the wake of the aerosol ban, especially when there is a large fixed capital investment left with excess capacity. A nonaerosol CFC quota would further complicate any remnants of a collusive agreement by effectively tying the markets for different CFCs together by their common dependence on permit availability. There is little reason to believe that collusion is an important factor to either the existing or the quota-regulated CFC market.

[15] This issue is discussed in more detail in Sec. III.

Effects on CFC Distributors

CFC distributors are less likely to be harmed by CFC regulation than any other identifiable group. For these firms, capital costs appear low, entry and exit appear relatively easy, and the costs of distribution are unaffected by CFC regulation. While the quota also "freezes" the total CFC distribution market, distributors should not bear the kind of excess capacity costs considered above for the CFC manufacturers. Distributors will not necessarily be harmed by any significant shift in CFC use away from the user categories where they now operate. In solvents, the amount of CFC-113 handled will decline, but largely in favor of other chemical solvents that existing distributors may already (or could) handle. Distributors are also prevalent in the refrigeration servicing markets, but these markets are extremely unlikely to reduce CFC use significantly under any of the policies considered in this report.

Effects on Competing Industries

One group of firms that will benefit under CFC regulation are those that now compete with the CFC-related industries. For example, firms that supply equipment or chemicals that can be used to reduce CFC use and firms that make substitute products for CFC-made products will experience an increase in the demand for their output. In the short run, these firms will benefit as prices and output levels increase. In the long run, the policy will induce entry, returning these industries to a competitive rate of return.[16]

[16] This assumes no barriers to entry in these industries.

Government Revenues

The sale of marketable permits in an auction generates government revenues. The market value of a permit is determined by the increase in the price of obtaining CFCs required to bring CFC demand into line with the restricted supply under the quota. Our estimate of the market value of permits under an efficient permit policy implies that government revenues (in 1976 dollars) from auctioning permits would come to \$32 million for permits good in 1981, rising to over \$956 million for permits good in 1990. If permits for 1981 through 1990 were auctioned today, the total revenues would amount to \$2,031 million.[17]

Table 2.3 identifies the industries from which these permit auction revenues would flow. Most industries would pay increasing amounts for permits over the next decade. However, makers of TPS foams used in packaging applications would stop buying permits by 1989; these firms will either be driven out of business by competing packing materials or will convert to non-CFC chemicals for foam manufacturing.

Like the increased production costs under a CFC quota, payments for permits will be shared by user firms and their consumers in the short run. In the long run, consumers indirectly will bear the brunt of these payments.[18] Thus, the permit auction defines a unique flow of wealth from consumers of CFC-made products, to the user firms, and then to the U.S. Treasury in the form of auction proceeds. Ultimately, the entire

[17] This is the discounted (at 11 percent) present value in 1976 dollars of 341 million permits good for the years 1981 through 1990. For a discussion of the 11 percent (real) discount rate, see Palmer et al. (1980a), Sec. II.

[18] Consumers eventually pay all costs in markets with perfectly elastic long-run supply curves.

Table 2.3
SOURCES OF PERMIT AUCTION REVENUES BY USER CATEGORY: 1981 TO 1990
(In \$ million 1976)

User Category	Transfer Payments											Cumulative ^a
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1990	
Flexible foam	3.4	9.6	13.0	18.6	21.3	19.5	13.9	16.4	18.8	22.7	94.2	
Solvents	5.8	16.2	23.6	33.1	44.1	53.0	60.1	67.8	75.9	95.7	259.5	
Rigid foam												
TPS	1.0	3.1	4.6	6.1	7.8	9.2	10.0	6.3	0.0	0.0	31.1	
Insulation	7.4	24.1	40.8	67.2	100.6	133.6	167.4	215.9	276.4	423.6	735.9	
Other	1.7	5.4	8.6	13.0	17.8	21.3	24.0	26.8	29.7	40.4	101.8	
Mobile air conditioning												
Manufacturing	2.8	8.4	12.7	18.2	23.4	26.4	28.1	29.8	31.2	39.8	123.5	
Servicing	4.6	14.3	23.0	36.0	51.2	64.7	77.1	94.6	115.4	171.9	338.8	
Retail food refrigeration	0.9	1.8	2.7	3.9	5.2	6.2	7.1	8.4	10.0	14.6	32.6	
Chillers	1.4	4.3	7.0	11.2	16.2	20.9	25.4	32.0	39.9	60.6	112.1	
Home refrigeration	0.5	1.7	2.7	4.2	6.1	7.7	9.2	11.3	13.9	20.8	40.4	
Miscellaneous	2.6	8.1	13.1	20.1	27.7	33.4	38.0	43.1	48.3	66.2	161.1	
Total ^b	32.3	97.1	152.0	231.4	321.3	395.9	460.4	552.4	659.6	956.4	2031.1	

NOTE: Transfer payments are estimated prior to rounding permit prices to the nearest cent.

^a Sum of annual transfer payments, discounted to 1981 at 11 percent.

^b Detail may not sum to totals due to rounding.

amount of the payments (aside from the government's administrative costs of operating the auction) flows to taxpayers, the final financial beneficiaries of a permit auction.

DIMENSIONS FOR POLICY EVALUATION

As a base case for comparing alternative permit policies, the permit auction provides a valuable benchmark. It identifies important dimensions along which permit policies might vary.

One such dimension is administrative feasibility or cost. A permit auction is straightforward, and auctions have been used in the past by agencies to sell off valuable assets. Notably, however, the use of an auction in the context of an artificial rationing device is not commonplace at any level of government, and could run afoul of the Constitutional restriction that only Congress is authorized to impose taxes. If permits cannot be sold without special legislation to allow it, then EPA must consider options for allocating permits, some of which could pose substantially higher administrative costs than the auction.

A second dimension for policy evaluation is regulation's costs to the economy as a whole. The permit auction, and certain allocation policies, minimize regulation's aggregate costs by ensuring an efficient allocation of resources in the private sector. As we shall see in later sections, however, some allocation policies introduce some allocative inefficiencies that raise regulation's costs to the economy as a whole.

The third evaluation dimension is the distribution of regulation's costs. Specifically, policymakers might wish to avoid, mitigate, or at

least provide compensation for the losses suffered by consumers, workers, and owners of firms under a permit auction.

A permit auction lies at one extreme of the trade-off between minimizing costs to the economy as a whole and mitigating regulation's impact on the CFC-related industries. Other permit policies make other trade-offs in these dimensions, while varying substantially in their administrative costs as well. In the following sections, we show how and why permit allocation policies vary along each of these dimensions of policy evaluation.

III. ALLOCATIONS TO THE CFC PRODUCERS

Of all the allocation options considered here, allocations to the CFC producers would be among the least costly to administer. There are only five domestic producers of the targeted CFCs. Even if the allocations were extended to include CFC importers, the total number of permit recipients would be small relative to other allocation proposals.[1] Although some allocation formulas might require data that are difficult to obtain or verify, the formulas would need to be calculated for only a small number of firms. And some formulas would be extremely simple to compute.

Any of the producer allocations we have studied would simply redirect the flow of transfer payments away from the general treasury to the CFC producers. We do not expect the allocations to affect economic outcomes for user industries--owners of user firms, their workers, or consumers of their products. Aside from the redistribution of wealth from the general treasury (taxpayers) to the owners of CFC-producing firms, the economic outcomes of allocations to the producers would match those of a permit auction.

Consequently, the principal differences among the allocation formulas lie in their administrative features and the way they distribute wealth among the CFC producers. The formulas examined here are designed

[1] We do not have data on the actual number of CFC bulk importers, but we know that total imports have historically been very limited and that the CFC producers themselves sometimes import certain CFCs for use in making others. The quantitative analysis in this section examines only the permit allocations to domestic producers, but the implications of allocations to importers are similar.

to reveal how the choice among alternative formulas can affect these outcomes.

ALLOCATION FORMULAS

Among the simplest producer allocations to administer are those that distribute transfer payment wealth according to some measure of CFC production. Three types of formulas we consider distribute permits in proportion to alternative measures of production levels.

The "historical-base" formula gives each producer a number of permits equal to his 1980 weighted production[2] of the regulated CFCs. Thus, firms that currently manufacture the largest amounts of CFCs receive the largest wealth transfers. The permits could represent annual rights and be reissued each year with the same number given to each firm every year. Or the permits can be issued once-and-for-all as perpetuities.

"Predicted-base" formulas allocate permits according to the producers' predicted shares of the regulated market over several policy years. These formulas take account of how firms' involvement in the CFC market will change over time under the quota. Under one such formula, each producer receives permits each year equal to his predicted production for that year; this formula would require annual permits, but each firm could be told in advance the number of permits it would receive for, say, ten years into the future. Alternatively, the number of permits a

[2] Because CFC uses as chemical intermediates would be exempted, and because in-house nonintermediate uses and production and distribution emissions are small, production nearly equals sales. The data used in this section actually refer to sales.

firm receives could match its predicted share of cumulative CFC production over the next decade as a whole; in this case, permits could be issued once as perpetuities.

Whereas predicted-base formulas allocate permits without regard to actual production levels in years after 1980, the "actual production" formula gives each firm a number of permits determined by its actual market shares in the preceding year. This formula avoids the need for predictive modeling, while quite accurately matching permit allocations to levels of production. Under this formula, permits must be reissued and reallocated every year.

At least in principle, yet other allocation formulas could be specified explicitly to provide compensation for underutilization of productive capacity. In particular, firms whose capacity utilization is most seriously hampered by the CFC quota might be granted relatively large numbers of permits. Below, we discuss the administrative difficulties inherent in using this type of formula, as well as the possible motivation for using it.

ADMINISTRATIVE ISSUES

The historical-base producer allocation would be the easiest and least costly to administer of any allocation option we have studied. The entitlement calculations require accurate data on 1980 production levels for individual firms. But precisely these same data are required for administering and enforcing a 1980 quota under an auction or any

permit allocation policy. And calculation of permit entitlements using those data is straightforward.[3]

Even under the historical-base formula, some measurement details must be resolved. For example, consider the treatment of CFC-502. The production process begins with CFC-114 which is converted to CFC-115 and then combined with CFC-22 to form CFC-502. Some firms purchase the CFC-114 or CFC-115 for the CFC-502 they sell. (Reportedly, some of the purchased CFC is imported.) Should the permits attributable to CFC-502 be allocated to that chemical's producer or to the producers (or importers) of the precursor CFCs? Though CFC-502 accounts for only about one percent of the permits to be issued, the (1981) present value of these permits over the next decade would amount to over \$13 million (in 1976 dollars), and the individual producers would not be indifferent to how this wealth is distributed.[4]

Setting permit entitlements under predicted-base formulas is complicated by the need to predict market shares in future years. The more sophisticated the model used to make the predictions, the more likely it is to require detailed data that could prove difficult to obtain or verify. Below, we illustrate the use of a crude model and discuss its possible shortcomings.

[3] A firm might reasonably argue that use of a single base year is unfair if, for example, the firm experienced a strike or unusual maintenance shutdown that year. For this reason, a historical-base policy could calculate permit shares using a multiyear base period. Collecting additional data would raise administrative costs somewhat, but the formula's revision would not fundamentally alter its economic effects.

[4] Since the treatment of CFC-502 affects only the distribution of wealth among the producers, we cannot offer any objective basis for choosing one answer to the question over another.

An allocation formula based on actual market shares avoids some of the pitfalls of a predicted-base formula.[5] Over time, predictions are increasingly likely to vary from reality. Certainly, the predictions cannot be made accurately into the indefinite future. A formula based on actual market shares does not require development or verification of a predictive model.

Under an actual production formula, the way production is measured can importantly affect the policy's outcomes. The formula under consideration here counts only production for which the producer has obtained permits (both from his allocation and from aftermarket purchases). This rule avoids giving producers an incentive to produce more than they are authorized to sell in a given year; without the rule, a producer would find it worthwhile to overproduce in order to obtain a larger subsequent permit allocation. Moreover, the formula considered here would not count production sold to another CFC producer, and no permit transaction would be required for such sales. This provides a mechanism for dealing with temporary production shortfalls, say, due to a strike or unusual maintenance problems. In such an event, a producer can buy CFCs from his competitors--just as producers do in today's unregulated market--and resell the CFCs as though he produced them himself. If this were not allowed, the producer might find it worthwhile to withhold his permits from the aftermarket, because doing so would decrease total market production and thus artificially increase the producer's

[5] There are advantages and disadvantages to the periodic reissuance of permits required by the actual production formula and some predicted-base formulas. See the discussion in Sec. II in the context of the choice between perpetuities and annual rights.

market share and inflate his subsequent permit allocation.[6] These are but two examples of the ways in which rules must be carefully specified to assure an actual production formula achieves its intended effects.

Perhaps the most important feature of the actual production formula considered here is its use of the ozone depletion factors to weight production for calculating permit allocations. As we explain below, the use of a different set of weighting factors for the allocation formula will create distortions in the CFC markets.

Allocations based on measures of capacity utilization pose especially difficult administrative problems. The capacity of a production facility is notoriously difficult to assess. A given plant can yield several different potential output levels, depending on the flexibility of its original design, the intensity with which it is operated, and the availability of opportunities for output-augmenting modifications. Moreover, some CFCs (such as CFC-11 and CFC-12) are produced jointly; the capacity for producing one CFC depends on the production level for the other, and the combined total capacity depends on the CFC mix. Devising a uniform code for evaluating capacity is analogous to defining income subject to taxation, a task that can absorb considerable administrative resources and yet not be accomplished to everyone's satisfaction.

[6] The producer in question will still produce a smaller share of total production and receive a smaller subsequent permit allocation than he would if his facilities had not experienced a shutdown. However, the producer will produce a larger share of the total and receive a larger subsequent permit allocation than he would if he sold his unused permits.

In summary, different producer allocation formulas would result in different administrative costs, with the historical-base formula being the least costly and the capacity-utilization formula probably the most costly. These administrative costs must be weighed against the desirability of the formulas' different effects on the distribution of wealth among the CFC producers.

OUTCOMES

None of the allocation formulas considered in this section would alter the market outcomes of a permit auction. The permit allocations do not affect what users are willing to pay to obtain CFCs, nor the production costs for the CFCs. A producer will sell permits (or leases) and forgo production when a competitor offers a permit (or lease) price greater than the difference between what users will pay and the producer's production costs.[7] (A firm will buy permits and increase production when a competitor accepts a permit (or lease) price less than this difference.) The producer's output levels should reflect only user demand and production cost conditions, with permits changing hands as needed to match production levels.[8] And, with production levels the same as under a permit auction, user prices, consumer prices, and other market outcomes would also match those of the permit auction. By

[7] This statement, which describes short-run profit maximization, represents a simplification for expository purposes. The analysis in this section assumes producer behavior is reasonably consistent with profit maximization, though not necessarily only over the short run.

[8] In Sec. II, we argued that collusion among the producers is unlikely under a permit auction. Under permit allocations to the producers, there is even less incentive for collusion than under an auction because the allocations automatically give producers the transfer payments generated by the CFC quota.

implication, the sole distinction between the outcomes of these producer allocations and those of a permit auction involves the way wealth is distributed.

To estimate wealth outcomes, we must first estimate the levels of CFC production by each producer. Estimates for 1980 are needed to compute permit entitlements under the historical-base formula. Estimates for 1981 and beyond are needed for the predicted-base formulas and to predict aftermarket transactions under the historical-base formula. The estimation methods described below also illustrate some of the administrative issues raised by using predicted-base formulas.

Estimating Production Levels

For proprietary reasons, some firms were reluctant to give us data on their individual production levels. Wolf (1980) estimated 1977 production levels under the admittedly crude assumption that firms' market shares for each CFC were proportional to published estimates of productive capacities. The resulting estimates proved to be reasonably consistent with other bits of evidence, and none of the producers has offered revised estimates. Table 3.1 estimates CFC production by firm for 1980, assuming market shares remained constant and using our own estimates of 1980 marketwide production.[9]

[9] In what follows, a firm's "market share" is its production of a given CFC as a fraction of total production of that CFC. In contrast, a firm's "share of total weighted production" is the weighted sum of its production of different CFCs as a fraction of total weighted output of all the CFCs. A firm's market share equals its share of total weighted production only by coincidence.

Table 3.1

ESTIMATED PRODUCERS' MARKET SHARES OF 1980 SALES:
CFC-11, CFC-12, CFC-113

Producer	^a Market Share (Percent)			Sales (Millions of Pounds)		
	CFC-11	CFC-12	CFC-113	CFC-11	CFC-12	CFC-113
Allied	22	21	33	28.7	39.2	25.8
DuPont	57	56	67	74.3	104.6	52.5
Kaiser	9	9	-	11.7	16.8	-
Pennwalt	10	10	-	13.0	18.7	-
Racon	2	4	-	2.6	7.5	-
^b Total	100	100	100	130.3	186.7	78.3

^a
Market shares assumed equal to shares of 1977 capacity by CFC, as estimated in Wolf (1980), Table V-2.

^b
Detail might not add to totals due to rounding.

The table accounts for 338.2 million weighted pounds of 1980 CFC sales, or 99 percent of the 341.0 million permits to be issued under a 1980 quota. The omitted one percent can be attributed to the omission of CFC-502 and rounding error. For our quantitative analysis, we examine permit allocations with reference to domestic producers' sales of CFC-11, -12, and -113, with the understanding that a small fraction of permits would remain to be allocated with reference to CFC-502 and imports.[10]

In Palmer and Quinn (1981), we estimated post-1980 marketwide production of CFC-11, -12, and -113 under a CFC quota combined with a

[10] If CFC-502 were exempt from the quota, 338.7 million permits would be issued.

permit auction.[11] Over the next decade, we expect decreased production of CFC-113 (and, to a lesser extent, CFC-12) to be offset by increased production of CFC-11. Previous estimates of overall CFC-11 and -12 capacity suggest it could nearly satisfy growth in domestic nonaerosol uses through 1990 (under a CFC quota), unless other uses and exports grow commensurately. If new capacity is added by the end of the decade, we assume it will be distributed among the producers in proportion to their existing capacity, perhaps through modification or renovation of existing facilities.

Market shares reflect the economics of the production processes used by different producers. Predicting market shares requires detailed data on the production function and input prices for each plant owned by each firm. Even if such data were readily available, the models required to analyze them would be complex; for example, the models would have to reflect the jointness of production for CFC-11 and -12. Detailed analysis of the determinants of CFC market shares is not possible with available data.

Throughout our quantitative analysis, we assume market shares for each CFC would remain constant under the quota. This assumption would be correct over the short run (a period when there is neither entry nor exit of firms) if all producers used the same production process for each CFC. For CFC-11 and -12, we do not expect entry over much of the next decade, and growth in the combined market should prevent exit. Although the CFC-11 and -12 producers use somewhat different production

[11] For this analysis, we use the estimates from Scenario VI of the cited document.

processes, there is some evidence that their average costs are fairly constant over a wide range of output; by implication, the conditions that created current market shares would tend to preserve those shares over the next several years. But constant market shares is a far more questionable assumption in the case of CFC-113, where the market will contract and the two producers have distinctly different production processes. Though market shares for CFC-113 are especially likely to change, we cannot predict how or to what extent the shares will change. Without more information, we must assume constant market shares, with the understanding that the assumption probably fits reality better for CFC-11 and -12 than for CFC-113.

Given estimated marketwide production under a permit auction, Table 3.2 estimates the producers' 1985 and 1990 levels of production if they maintain their 1980 estimated market shares for each CFC. Growth in the total markets for CFC-11 and -12 is shared proportionately by the five producers. Decline in the market for CFC-113 is shared proportionately by Allied and DuPont.

The Historical-Base Formula

Table 3.3 describes permit allocations under the historical-base formula. The number of permits each firm receives equals the weighted sum of the 1980 CFC sales levels estimated in Table 3.1. In any given year, the market value of a permit would approximately equal the price it would bring in an annual permit auction.[12] Using the permit

[12] If permits are issued as perpetuities, the market value in a given year refers to the price that would be obtained for a lease to use the permit for that year.

Table 3.2

CFC PRODUCTION TO MAINTAIN MARKET
SHARES UNDER REGULATION

Producer	(Millions of Pounds)		
	CFC-11	CFC-12	CFC-113
1985			
Allied	30.9	40.1	20.1
DuPont	80.1	107.0	40.8
Kaiser	12.6	17.1	-
Pennwalt	14.0	19.1	-
Racon	2.8	7.6	-
^a			
Total	140.4	191.0	60.9
1990			
Allied	36.4	36.8	14.7
DuPont	94.3	98.0	29.8
Kaiser	14.9	15.8	-
Pennwalt	16.6	17.5	-
Racon	3.3	7.0	-
^a			
Total	165.5	175.5	44.5

^a
Detail may not add to totals due to rounding.

auction prices in Table 2.1, Table 3.3 shows the 1981 and 1990 values of the permit allocations. The table's final column reports the present value of the permit allocations over the decade as a whole.[13]

[13] This estimate does not equal the total present value of the permits because it omits their valuation for years after 1990. Suppose the annual value of permits stabilizes at the 1990 level of \$2.80, the price of a perpetuity in 1981 would be nearly \$16. Then, the present value of each firm's allocation would be nearly three times higher than the level indicated in Table 3.3.

Each firm's permit allocation matches its estimated weighted production in 1980, but not in later years. To allow this, permits must be traded among the producers. For example, Table 3.4 predicts the number of permits (or leases) each firm would buy or sell in the years 1985 and 1990 to maintain constant market shares. Over the decade as a whole, Allied and DuPont would be net sellers of permits, and the remaining firms would be net buyers.

Table 3.3

CFC PRODUCERS' TRANSFERS RECEIPTS UNDER ALLOCATION
BY ESTIMATED 1980 MARKET SHARES

Producer	Millions of Permits	Permit Valuation (Millions of 1976 Dollars)		
		1981	1990	Discounted Cumulative 1981-1990
Allied	79.5	7.2	222.6	472.7
DuPont	197.4	17.8	552.7	1,173.8
Kaiser	25.0	2.2	70.0	148.7
Pennwalt	27.8	2.5	77.8	165.3
Racon	8.5	0.8	23.8	50.5
^a Total	^b 338.2	30.4	947.0	2,011.1

NOTE: Estimates assume permits must be used at the rate of one weighted pound per year (i.e., without holdovers or futures trading). Permits issued once as perpetuities or reissued annually.

^a

Detail may not add to totals due to rounding.

^b

Omits 2.8 million permits issued under the policy analyzed in Palmer and Quinn (1981). See text.

^c

Based on estimated equilibrium permit prices from Table 2.1.

^d

Discounted to 1981 at 11 percent per year. The present value of a permit used from 1981 through 1990 is approximately \$5.95.

Permit trading among the producers promotes an efficient use of resources in CFC production, but also imposes some transactions costs on the economy. And, because the prices users will pay for CFCs are determined only by their demand and the CFC quota level, the transactions costs are borne entirely by the CFC producers. Transactions costs promise to be small relative to other costs imposed by CFC regulation, but nevertheless deserve recognition because they vary from one permit policy to another. The historical-base formula requires more permit trading--and thus imposes higher transactions costs--than certain other allocation formulas, as described below.

Predicted-Base Formulas

Over the next decade, the domestic CFC producers would sell nearly 3.4 billion weighted pounds of CFC-11, -12, and -113 under the CFC

Table 3.4

PREDICTED PERMIT TRADING UNDER 1980-BASED ALLOCATIONS TO CFC PRODUCERS

(Millions of permits)

Producer	1985		1990	
	Permit Purchases	Permit Sales	Permit Purchases	Permit Sales
Allied	-	1.5	-	2.7
DuPont	-	1.5	-	2.6
Kaiser	1.2	-	2.4	-
Pennwalt	1.3	-	2.6	-
Racon	0.4	-	0.3	-
^a				
Total	3.0	3.0	5.3	5.3

^a
Detail may not add to totals due to rounding.

quota. The constant market shares assumption implies the producers would share this cumulative market as follows: Allied, 23.2 percent; DuPont, 58.1 percent; Kaiser, 7.7 percent; Pennwalt, 8.6 percent; and Racon, 2.4 percent.

Permit perpetuities could be allocated according to the foregoing percentages. The producers would receive the following millions of permits: Allied, 78.5; DuPont, 196.5; Kaiser, 26.0; Pennwalt, 29.1; and Racon, 8.1. In contrast with the historical-base formula's outcomes, Allied and DuPont would buy permits (or leases) from Kaiser and Pennwalt during early years; for the decade as a whole, the number of permits (or leases) changing hands would be only somewhat less than under the historical-base formula. Relative to the historical-base formula, this predicted-base formula gives Allied and DuPont far fewer permits and thus much less wealth; Racon receives slightly less wealth, and the other two firms receive more.

To reduce permit transactions further, annual permits could be reallocated each year according to predicted annual market shares. From existing data and models, each firm could be told for ten years in advance the number of permits it would receive, but the number would vary from one year to another. Our models predict that no permit transactions would be necessary under this allocation plan, though some would surely occur simply because of variations in actual market shares around the predicted values.

The two predicted-base formulas yield wealth distributions that differ from one another. Allied and DuPont are better off under the predicted-base formula that allocates perpetuities according to

cumulative market shares.[14] These two firms would buy permits (or leases) in early policy years when the permit values are low, and sell about the same number of permits (or leases) in later years when permit values are much higher. The remaining firms would be better off under the permit allocations based on predicted annual market shares. These differences in the wealth distributions between two predicted-base formulas doubtlessly outweigh the differences between them in the transactions costs associated with permit trading.

Allocations Based on Actual Annual Production

Like the predicted-base formula that allocates according to predicted annual market shares, an allocation based on actual annual production reduces the degree of permit trading. Some trading will surely occur under either formula. Under the predicted-base formula, trading will occur because predictions vary from reality. Under the annual-production formula, trading will occur because the market shares in a year will not precisely match those of the preceding year. But either formula should produce considerably less trading than the historical-base formula or the predicted-base formula using cumulative market shares.

As specified, the actual production formula examined here does not produce market distortions. In principle, the formula subsidizes production; a firm can receive valuable permits for free by increasing its level of CFC production and sales. However, the CFC quota (embodied in

[14] Of course, Allied and DuPont would prefer the historical-base formula to either of the predicted-base formulas.

the limited availability of permits) assures that the subsidy cannot cause an increase in total weighted production. Moreover, the formula considered here requires a firm to buy an additional permit in order to obtain an additional permit by allocation in the succeeding year-- regardless of which CFC the firm produces.[15] The formula maintains the quota and provides no incentive to change the mix of CFCs in production--and thus yields the same user market outcomes as a permit auction.

Notably, a different specification of the formula would produce market distortions.[16] Suppose that, while a permit would still be required to produce and sell a weighted pound of any CFC, the allocation formula distributes permits according to firms' shares of total unweighted output. For example, increasing CFC-113 production by one (unweighted) pound would be just as effective in increasing the subsequent permit allocation as increasing CFC-11 production by one pound. However, while the firm must buy one permit to expand CFC-11 production by one pound, the firm must buy only 0.77 permits to expand CFC-113

[15] Given the weights in Table 1.1, the firm can get one more allocated permit next year by adding one pound to current CFC-11 production or by adding 1.3 pounds to current CFC-113 production. In either case, the firm will have to purchase one additional permit in the current year.

[16] The model used to reach this conclusion is like the model of final product allocations to end users, which is presented in the appendix. The differences are that the producer's output is a^i (instead of q^i); he must obtain $\delta^i a^i$ permits to produce that output (where δ^i is the i th CFC's ozone-depletion factor); and the producer has no TRS (i.e., $m^i \equiv 0$). The market distortions described here in the text result when $w^i \neq \delta^i$ (where w^i is the weight used to calculate the firm's share of the permit allocation).

production by one pound. Therefore, other things equal,[17] the firm would prefer to expand CFC-113 production and cut back on CFC-11 production. To sell the revised output mix, firms would reduce CFC-113 prices relative to those for CFC-11. Users of CFC-113 would engage in less technological adjustment to control CFC use, and they would charge their customers lower product prices than under an auction. But this benefit to CFC-113 users would come at the expense of higher costs to CFC-11 users and their customers as well as higher resource costs to the economy as a whole. In general, any revision to the actual production formula we have specified will produce market distortions.

By avoiding market distortions, the actual production allocation formula we originally specified would result in each producer maintaining the same market shares as under a permit auction or any of the producer allocation formulas discussed above.[18] Therefore, our predictions for the number of permits each producer would receive would match those for the predicted-base formula in which permits are reallocated annually, except the actual production allocations would be lagged by one year. Otherwise, all outcomes for this formula would match those of the predicted-base annual allocations.

[17] "Other things"--such as the demand schedules for CFC-11 and -113--are not equal. However, except under extreme conditions, the allocation formula under consideration would cause expansion of CFC-113 supply and contraction of CFC-11 supply.

[18] Consider: The subsidy implied by the allocation formula is determined by the equilibrium market value of a permit. Since this value is the same for all producers, the subsidy to the marginal unit of production for a given CFC is the same for all firms and all production facilities. Assuming only that shares of the total market for a CFC are competitively determined, the implication is that market shares with the subsidy will equal those without the subsidy.

Formulas Based on Capacity Underutilization

In the absence of a CFC quota, growth in CFC markets would lead to greater utilization of existing excess capacity. To the extent that excess capacity currently exists because firms efficiently planned for market growth, the quota devalues past capital investment.

In principle, permits could be allocated to the producers in proportion to the policy-induced devaluation of capital. Measuring that devaluation is exceedingly difficult. Here we consider how a naive measure would affect permit allocations.

The assumptions by which we would predict constant market shares also imply that all firms would have the same capacity utilization rates for a given CFC in a given year. Therefore, for a single CFC, allocating permits in proportion to predicted production of the CFC would equal allocating permits in proportion to (predicted) underutilization of capacity. [19]

Consequently, if the constant market shares assumption were correct (or nearly so), the principal difference between using a capacity-based formula and using a predicted-base formula would lie in the way permits are allocated among different CFCs. Under predicted-base formulas, the total number of permits allocated for, say, CFC-11 production depends on marketwide CFC-11 output as a fraction of total weighted production; for example, CFC-11 would account for about 52 percent of 1980 through 1990

[19] For the i th firm, capacity (C_i) equals production (P_i) plus unused capacity (U_i). Equal capacity utilization means P_i/C_i is equal for all i . When a total of A^* permits are allocated according to production shares, a firm's allocation (A_i) is given by $A_i = (P_i/\sum_i P_i)A^*$. Given $C_i = P_i + U_i$ and $P_i/C_i = a$ constant for all i , it is easy to show that $P_i/\sum_i P_i = U_i/\sum_i U_i$. Note that the policy considered here uses predicted values of U_i to avoid causing market distortions.

cumulative weighted production under a quota, so the predicted-base formulas allocate 52 percent of the permits among the producers according to their market shares of CFC-11 sales. Under a capacity-based formula, the number of permits allocated with reference to CFC-11 would be a function of the effects of the CFC quota on CFC-11 capacity use relative to effects on capacity use for the other CFCs.

The CFC quota will cause more capacity underutilization for CFC-113 than for the other CFCs. In the absence of regulation, the markets for the three CFCs would grow at similar rates, but under regulation the market for CFC-113 declines while the combined CFC-11 and -12 market grows. A capacity-base formula might therefore allocate more permits for CFC-113, and thus give larger allocations to Allied and DuPont, than do the other formulas we have analyzed.

EVALUATION

The principal advantage of allocations to producers over other permit allocations lies in low administrative costs. And, of the producer allocation formulas we have examined, the historical-base formula appears to offer the lowest administrative cost.

The producer allocation formulas specified at the beginning of this section are all "neutral." Under a neutral policy, the permit allocations do not affect production costs or what users are willing to pay--and a producer's decision to buy or sell permits does not affect his permit allocation. Consequently, the producers make the same production and pricing decisions they would under a permit auction. Users must pay the same amounts for CFCs that they would under a permit auction, and

thus plant closures, worker unemployment, consumer prices, and other user industry outcomes would be the same as under a permit auction. Under any neutral allocation formula, the CFC quota's cost to the economy as a whole (resource costs) and the distribution of the cost burden (resource costs plus transfer payments) among user industries would be the same as under a permit auction.

It is possible to design nonneutral producer allocation policies. One example we gave would allocate permits according to actual shares of total unweighted production, but there are others. By differentially subsidizing the production or sale of different CFCs, nonneutral allocations change the mix of CFCs in production. Relative to a permit auction, plant closures, worker unemployment, and consumer prices will be less in industries that use the most heavily subsidized CFCs, but greater in the industries that use the least heavily subsidized CFCs. Nonneutral producer allocations can benefit some user industries, but only at the expense of others--and only through an increase in the CFC quota's aggregate resource costs.

As a group, the CFC producers would be better off under a producer allocation (neutral or nonneutral) than in the absence of any CFC regulation.[20] This is true because the wealth transfer surely exceeds any loss from producers' capital devaluation due to regulation. By the end of the decade, existing CFC-11 and -12 capacity should be fully utilized even under the CFC quota; the return to this part of the capital stock is reduced only to a modest degree because it would have been fully

[20] This conclusion derives from Sec. II's argument that the unregulated CFC markets are noncollusive.

utilized only slightly sooner in the absence of regulation. Though CFC-113 capacity will be substantially underutilized under regulation, much of the underutilization is more properly attributed to the aerosol ban, which drastically cut production of the CFC-114 produced in conjunction with CFC-113. In any case, the formulas we have studied would transfer more wealth to Allied and DuPont than can reasonably be attributed to compensation for forgone returns to CFC-113-producing capital.

Allocations to the CFC producers avoid a large inflow of permit payments to the general treasury, and can be accomplished with great administrative simplicity. Whether the resulting distribution of wealth is desirable is a matter for policymakers to judge.

IV. NEUTRAL ALLOCATIONS TO END USERS: "THE-BUCK-STOP-HERE" FORMULAS

The formulas considered in this section allocate permits to firms that purchase CFCs for use in making or servicing products, such as furniture cushions or refrigerators. Relative to producer allocations, these formulas are far more costly to administer, but distribute wealth to a far larger number of firms. And the firms that receive the wealth belong to the industries that generate transfer payments under a CFC quota.

However, under all the formulas considered in this section, the permit allocation "buck" stays in the hands of the immediate permit recipients. None of the formulas provide an incentive for the owners of CFC-using firms to pass through the benefits from permit allocations to their workers or customers. Receiving permits under these formulas would not change a businessman's decisions about whether to remain in business, how much output to produce, or what price to charge for his products. Relative to a permit auction, these end-user allocations simply redistribute wealth from the general treasury (taxpayers) to the owners of CFC-using firms.

The reason workers and consumers do not benefit from the allocation formulas in this section is that each firm receives full and invariant property rights to its permit allocation. The firm is free to retain the permits for its own use or sell the permits. Entitlements to allocations do not vary with a firm's decisions to cut back on CFC use, to reduce production of final products, or even to go out of business

altogether. In short, the allocations examined here are neutral in their effects on private-sector business decisions.

Allocations that are revised in the light of behavior by firms lead to quite different economic implications, and are separately considered in the following section.

ALLOCATION FORMULAS

The "historical-base" formula we consider gives each existing firm a number of permits equal to its 1980 weighted use of CFCs. The permits can be given out once as perpetuities. This is a straightforward "grandfathering" option. It benefits firms that are in business when regulation is first implemented in proportion to their role in the regulated market at that time.

In contrast, "predicted-base" formulas take account of predicted user industry growth rates over the next decade. The predicted-baseline formula allocates permits to each user industry according to its predicted share of cumulative weighted CFC use over the next decade in the absence of regulation--then allocates the industry's permits to individual firms according to their shares of current industry CFC use.[1] Relative to the historical-base formula, this allocation gives

[1] Note that only existing firms receive permits under this formula, even though industry growth might have taken place through entry of new firms. In principle, some permits could be granted to grandfather firms temporarily, with the understanding that these permits would eventually be transferred (reallocated) to new entrants. In reality, making such a formula work without making permit allocations conditional on the behavior of firms would be virtually impossible--and if the allocations were conditional on firm behavior, they would not lead to economic implications cited in this section.

more permits to firms whose CFC use would have grown relatively rapidly in the absence of regulation.

The "predicted-regulated" formula is computed in the same way, except industry shares are defined by predicted use under the CFC quota. Industries that have few technological opportunities receive relatively more permits under this formula. In effect, the predicted-regulated formula gives each industry permits in proportion to its predicted share of the transfer payments that would have been generated by a permit auction.

Either of the predicted-base formulas just described could be based on a single calculation of cumulative shares of use. Then the permits could be issued once, as perpetuities. Or the number of permits a firm receives could vary from one year to another, based on the predicted share of use for each year. In this case, permits would have to be reissued annually, but each firm's entitlements could be prespecified for several years into the future.

In principle, permits could be allocated to end users according to other, quite different formulas. For example, permits could be apportioned among user industries based on some measure of the importance or value of the end products produced by that industry, with firms within the industry receiving permits according to their historical or predicted shares of the industry's CFC use. Such alternative formulas affect the distribution of wealth among the end users and the cost of administering the permit allocations--but do not affect other economic outcomes of the policy provided the permits are allocated as full and invariant rights.

ADMINISTRATIVE ISSUES

Administering the formulas described above requires data on CFC use by individual firms. The historical-base formula requires such data for 1980. The predicted-base formulas (baseline and regulated) also require 1980 use data to identify each firm's share of use within an industry. Enforcing and monitoring the CFC quota itself do not require these data, which would have to be collected and verified solely for the purpose of administering the end-user permit allocations.

The predicted-base formulas also require a model to predict future baseline or regulated CFC use in each industry. Such a model is available from Palmer and Quinn (1981). However, this model might require updating in the light of more recent data.

Under end-user allocations, the number of eligible permit recipients is potentially very large. There are hundreds of thousands of CFC-using firms--over 140,000 that install and service CFC-using mobile air conditioning units alone. Though calculating permit entitlements need be done only once (or, perhaps, once per decade), the large number of individual entitlements to be calculated makes allocations to end users more costly to administer than, say, allocations to the CFC producers.

Because of the large number of end-user firms, administrative costs could be substantial. Suppose, in the extreme, that as many as 250,000 firms were eligible and that the cost of obtaining and verifying data plus computing the permit entitlement were as high as \$100 per firm.[2]

[2] On the basis of extensive experience, the Rand Survey Research Group estimates that it costs \$100-\$200 per case for a one- to two-hour in-person interview of a respondent asked to provide written documentation of expenditures on various budget items. This assumes some non-

If permits were issued as perpetuities, the one-time-only administrative cost would come to \$25 million (in 1981 dollars).

This cost does not necessarily have to be paid by the government. Some or all of the cost could be laid off on the recipient firms. For example, the agency might institute a service fee. Total administrative costs could be recovered at a fee of \$100 per firm, or alternatively, \$.07 per permit.[3] Or the agency might require firms to submit all the necessary data and calculations to a central location, and the agency would then need only to audit the submissions. Because the value of the permits firms would receive is in the billions of dollars, firms would be more than willing to absorb the \$25 million or less it would cost to administer the policy.

A basic administrative problem will be verifying end-user status. CFCs sometimes change hands several times between the producer and the end user, passing through several stages of the distribution network. A given pound of CFC can be purchased several times over, but enter an end use only once. To receive permit allocations, firms have incentives to identify themselves as CFC purchasers, but not as CFC resellers. Some distributors might submit CFC purchase invoices in order to claim permit entitlements. And some end users who also act as distributors

response, some travel time to the respondent's location, and some missed appointments. Costs could be much lower in the case at hand because firms face a considerable financial incentive to cooperate, and costs would be lower still if the interviews were conducted at a central location rather than at the firm. The estimate is intended to be a gross overestimate of what a contractor might charge the government to perform this work.

[3] Efficient pricing policy would involve charging the firm a flat fee for the basic service, perhaps with an added charge per permit to reflect differences in the amount of data to be collected from each firm.

might claim more entitlements than are warranted by their actual end use.

To solve this problem (or, at least, to reduce its magnitude) it may be necessary to document the entire chain of CFC transactions that occurred in 1980.[4] This would not be a trivial exercise, and perfect reconciliation of all the data is probably impossible. But the task need be performed only once under the end-user allocation formulas considered in this section.

In contrast with allocations to the CFC producers, allocations to end users require no special decisionmaking for CFC-502. Permits would be allocated in reference to the weighted amount of CFC-502 use just as in reference to amounts of other CFCs.

OUTCOMES

Permit allocations to end users do not affect the fact that the CFC quota raises the cost of using a pound of CFCs. If a user could cut his CFC use by one pound, he could sell a permit; if he continues to use the pound of CFC, he must forgo selling the permit. Regardless of whether a businessman must buy a permit in an auction or forgo selling one he received by direct allocation, the total "cost" of using a pound of CFC is the same.

Given that the cost of using CFCs is the same under either a permit auction or end-user allocations, the business decisions that are most

[4] Alternatively, it might be possible to establish reasonable criteria for end-user status, such as proof of final product sales. The administrative costs estimated above would be sufficient to cover documentation of such criteria.

profitable under a permit auction are also most profitable under end-user allocations. It makes sense for the businessman to produce the same output, use the same input mix, and charge the same product price in either case.

There is, of course, a difference between a permit auction and end-user allocations in the asset levels of user firms. Firms are wealthier under the end-user allocations. Other things equal, wealthier firms may be better able to weather the consequences of bad business decisions or to allocate funds to new ventures or to capital investment.

Nevertheless, our predictions of market outcomes under a permit auction and under end-user allocations are the same. When we predicted the effects of a permit auction, we did not attempt to evaluate the chances that firms would make bad business decisions.[5] And our analysis of capital requirements for an efficient response to the production cap suggests that few firms would have trouble meeting those requirements. User firms will surely be wealthier under end-user allocations than under a permit auction, but this should have little effect on the way they produce or market their products.

Relative to a permit auction, end users will be wealthier by about \$32 million in 1981, and by about \$956 million in 1990. These are the respective annual values of the 341 million permits issued under the CFC quota.

[5] No doubt, the CFC quota alters the firm's decisionmaking environment. But the change in cost conditions is gradual under the cap, and firms have far more information--by virtue of EPA-sponsored research--about the changed conditions than is usually the case.

How much wealth each firm receives depends on how the permits are allocated among industries--and among firms within industries--under alternative formulas.

The Historical-Base Formula

Table 4.1 reports the estimated distribution of permits among user industries under the historical-base formula (assuming all permits are allocated to end users).

The size of allocations to individual firms would cover an enormous range. Together, the three largest U.S. automakers would split up over 85 percent of the 30 million permits available to mobile air conditioner manufacturers. A large maker of flexible or rigid foams or a very large solvent user would receive over a million permits. The smallest numbers of permits would probably go to servicers of home refrigeration and vehicle air conditioner units. Such firms might receive as many as a few hundred permits.

The historical-base formula gives some industries far more permits than they would use over the next decade, and some industries far fewer. Table 4.2 indicates the aftermarket permit transactions that would occur in 1985 and 1990. The insulation industry, because of its rapid projected growth, would be buying substantial numbers of permits throughout the next decade. Solvent users would sell large numbers of permits. As might be expected, the volume of postallocation permit trading, and

Table 4.1

PERMIT ALLOCATIONS TO END USERS BASED ON 1980 CFC PURCHASES

User Category	Millions of Allocated Permits ^a	Value of Permits Received ^b (In \$ Millions 1976)		
		1981	1990	Discounted Cumulative ^c 1981-1990
Flexible foams	46.8	4.2	131.0	278.3
Solvents	60.3	5.4	168.9	358.6
Rigid foams				
Insulation	72.3	6.5	202.4	429.9
TPS packaging	11.5	1.0	32.2	68.4
Other noninsulation	17.1	1.5	47.9	101.7
Mobile air conditioning				
Manufacturing	30.0	2.7	84.0	178.4
Servicing	47.6	4.3	133.3	283.0
Home refrigeration	5.6	0.5	15.7	33.3
Retail food refrigeration ^d	10.8	1.0	30.3	64.2
Chillers ^e	13.7	1.2	38.4	81.5
Miscellaneous	25.3	2.3	70.8	150.4
Total ^f	341.0	32.3	956.4	2,031.1

NOTE: Permit values used in these calculations assume a permit must be used to purchase one weighted pound each year (i.e., without hold-overs or futures trading).

^a Permits issued once as perpetuities or reissued annually.

^b Based on estimated equilibrium permit prices from Table 2.1.

^c Sum of annual values of permits received, discounted to 1981 at 11 percent.

^d Includes 2.3 million permits issued for CFC-502 use in 1980.

^e Estimates include permit allocations for CFC-12 contained in CFC-500.

^f Detail may not add to totals due to rounding.

Table 4.2
PERMIT TRADING UNDER 1980-BASED END-USER ALLOCATIONS
(Millions of permits)

User Category	1985		1990	
	Permit Purchases	Permit Sales	Permit Purchases	Permit Sales
Flexible foams	-	24.2	-	38.7
Solvents	-	13.5	-	20.8
Rigid foams				
Insulation	34.5	-	78.8	-
TPS packaging	-	3.2	-	11.5
Other noninsulation	1.8	-	-	2.7
Mobile air conditioning				
Manufacturing	-	5.2	-	15.8
Servicing	6.7	-	13.7	-
Home refrigeration	0.8	-	1.8	-
Retail food refrigeration	-	5.3	-	5.6
Chillers	3.5	-	7.9	-
Miscellaneous	4.1	-	-	1.7
Total	51.4	51.4	102.2	102.2

NOTE: The estimated 1985 and 1990 permit prices are \$0.94 and \$2.80, respectively.

thus the level of transaction costs, under this formula is far greater than under a historical-based allocation to the CFC producers.[6]

The Predicted-Base Formulas

Table 4.3 summarizes the comparisons between the historical-base and the two types of predicted-base formulas we consider. The first column repeats the historical-base allocation. The second and third columns show allocations for the predicted-baseline formula and

[6] Of course, the transactions costs associated with the end-user allocations would be borne by the end-user industries (their owners, workers, and consumers).

Table 4.3
END-USER PERMIT ALLOCATIONS UNDER ALTERNATIVE FORMULAS
(Millions of permits)

User Category	Basis of Allocations		
	1980 Use	Cumulative ^a Baseline Use	Cumulative ^b Regulated Use
Flexible foams	46.8	44.2	22.9
Solvents	60.3	60.7	48.5
Rigid foams			
Insulation	72.3	84.3	109.2
TPS packaging	11.5	11.0	7.4
Other noninsulation	17.1	18.7	17.6
Mobile air conditioning			
Manufacturing	30.0	24.0	23.8
Servicing	47.6	42.3	54.5
Home refrigeration	5.6	5.0	5.8
Retail food refrigeration	10.8	8.2	6.4
Chillers	13.7	13.1	17.4
Miscellaneous	25.3	29.3	27.4
Total	341.0	341.0	341.0

^a

User industry allocation equals 341.0 million permits multiplied by industry's share of estimated cumulative unregulated CFC use, 1980 through 1990.

^b

User industry allocation equals 341.0 million permits multiplied by industry's share of estimated cumulative regulated CFC use, 1980 through 1990.

predicted-regulated formulas, respectively. In all cases, the permits could be allocated once-and-for-all as perpetuities. Alternatively, if the predicted-base formulas were used to allocate different numbers of permits in different years, the allocations in the table would be the average number of annual permits each industry would receive over the next decade.

The predicted-baseline formula allocates permits much like the historical-base formula, suggesting that there is relatively little difference in the resulting wealth distributions to trade off against the differences in administrative costs for the two formulas.

In contrast, the predicted-regulated formula produces quite a different distribution of wealth, one much more closely attuned to the level of transfer payments that would flow out of each user industry under a permit auction. This formula also results in fewer aftermarket permit transactions (and thus lower transactions costs) than under the other two formulas.

EVALUATION

Compared to allocations to the CFC producers, end-user allocations impose higher administrative costs but distribute transfer payment wealth to a much larger number of firms.[7] If a wider distribution of the wealth is desirable, the higher administrative costs might be worthwhile. Or, if Congress and the courts will allow it, the government might recover the administrative costs by charging permit recipients a service fee or withholding some of the permits from allocation, selling them at auction to generate revenues.

Though they distribute wealth widely, the end-user allocations in this section allocate wealth to recipients in excess of their losses

[7] Because this section's end-user allocation formulas need be computed only once (or only once every several years), the administrative costs are borne just once (or infrequently). But the wealth transfers generated by the permit allocations continue to exist for as long as the CFC quota remains a binding constraint on CFC use.

due to a CFC production cap.[8] Most of the losses are borne by the consumers of CFC-using products. Regulation also imposes (short-run) losses on workers and owners of firms to the extent that it devalues their existing fixed investments in skills and physical capital. Yet the allocations considered here transfer wealth only to the owners of CFC-using firms, leaving workers and consumers uncompensated.

A potentially embarrassing artifact of this policy is that some owners will be observed to shut down their businesses after receiving considerable government assistance in the form of permit allocations. Some of the wealth the firm's owner receives might represent fair compensation for his prior investments that become unprofitable because of regulation and cannot be sold for their full value. But in at least some potentially visible cases, the firm's owner will receive payments far in excess of any reasonable estimate of his losses, and the workers he fires and the customers he stops serving will receive no compensation at all.

Previous analysis (Palmer and Quinn, 1981) suggests that thermoformed polystyrene foam makers are the user firms most likely to go out of business by 1990 under a CFC production cap. A TPS foam plant uses 350,000 to 750,000 pounds of CFC-12 per year, making the plant's owner eligible for 0.28 to 0.59 million permits. If the owner closed a plant and fired his workers in 1990, he would be able to sell permit leases worth between \$0.8 and \$1.7 million for that year alone. And the former plant owner would be able to sell permit leases in later years as well.

[8] There could be some exceptions for individual firms, but the majority would receive wealth in excess of their losses.

The exit of firms under the end-user allocation formulas in this section results from market forces pressing for an efficient allocation of the economy's resources under the CFC quota. Exit of firms (and consequent worker unemployment) can be avoided, at some cost in terms of economic efficiency. Methods of doing this, and the costs it imposes, are the subject of the following section.

V. ALLOCATIONS TO END USERS: "TRICKLE DOWN" FORMULAS

The allocation rules of the preceding sections are neutral in their impact on resource use. The allocations stop the permit auction's flow of wealth to the U.S. Treasury, returning this wealth to certain firms within the CFC-related industries. But because the policies provide no incentive for permit recipients to pass the benefits on, the compensation "buck" stops with the individuals or firms who initially receive permits. None of the neutral policies ameliorates the effects of regulation on consumer prices, prevents plant closures, or avoids the cut-backs in output that would occur under a permit auction. Consequently, none of the neutral permit policies reduces or compensates for the potential losses suffered by consumers and workers in the CFC-user industries or by firms that would otherwise supply the CFC-using industries with larger amounts of materials or services.

In contrast, this section examines allocation rules specifically designed to spread the benefits of compensation. Under these policies, permits are given to user firms. But these firms face incentives to pass through--or "trickle down"--some compensation benefits to consumers, workers, and other groups who would not benefit from the neutral policies.

Though the trickle-down allocation formulas meet the criteria for compensating regulation's losers, the rules have some disadvantages. They are among the most difficult and costly to administer of all the allocation plans we have considered. And avoiding plant closures, worker lay-offs, and higher consumer prices entails costs to the economy from a less efficient use of productive resources. This section spells

out in more detail the trade-offs involved in using trickle-down allocations.

THE ALLOCATION FORMULA

The trickle-down formula we analyze in detail uses a final product allocation rule. Under this formula, permits represent annual rights and are reallocated each year. The number of permits received by a user firm depends upon the firm's activity over time. Specifically, a firm's share of the total allocation is determined by its share of final product output. If a firm increases (decreases) its output level relative to other regulated firms, its permit allocation will increase (decrease). Thus, the final product allocation formula encourages firms to expand their output relative to a permit auction or neutral allocation policy. This restrains the rise in consumer prices and decline in employment levels, but also creates some inefficiency in private sector resource use.

Why would such an indirect and somewhat inefficient method be relied upon to benefit consumers, workers, and other participants in the CFC-related industries? Conceptually, these targeted groups could be designated as the direct recipients of some or all of the permits under a neutral (and thus more efficient) allocation formula. However, in reality, direct compensation promises to be less accurate, less effective, and administratively more costly than a trickle-down allocation.

The obstacles to direct compensation are perhaps most formidable with regard to final product consumers.[1] Virtually every man, woman, and child in the United States consumes CFC-made products, though in varying amounts. Attempting to distribute permits to all these individuals in amounts appropriate to the losses they suffer from regulation would be an administrative nightmare. Because few of these individuals buy or sell CFCs themselves, they would have to sell the permits to someone who does. The typical individual, having received only a handful of permits, would find that transactions costs absorb most of the permit redemption value.[2] What society would pay to achieve direct compensation--in administrative and transactions costs--would offset much, if not all, of the transfer payment wealth available for redistribution.

In contrast, a final product allocation formula avoids the obstacles that promise to overwhelm direct compensation. The final product allocations necessarily will be "on target," because they act directly on the increased production costs, higher prices, and reduced output levels that cause most consumer and worker losses.[3] As a result, the

[1] Directly compensating workers harmed by CFC regulation is only slightly less difficult. There are fewer of them than of harmed consumers, to be sure. But the amount of loss per worker is especially difficult to assess, because workers lose only to the extent that they currently possess skills or talents made obsolete by CFC regulation. For a discussion of targeting problems in the context of the compensation of workers harmed by regulation, see Goldfarb (1980).

[2] Indeed, a substantial share of the permits might not be redeemed at all due to transactions costs. As a result, the policy would effectively be more restrictive than policymakers intended.

[3] Caveat: Owners of human or physical capital that is CFC-specific (as contrasted with firm- or industry-specific capital) will not be compensated for losses if their firms stop using CFCs, even under the final product allocations.

policy maker need not identify specific individuals for compensation; this function is, in effect, performed by the market itself. The policy grants permits to the firms that actually use CFCs, thereby avoiding excessive transactions costs. Finally, although the policy portends high administrative costs, the recipients of permits under this formula are obviously no more numerous than under the "buck-stops-here" formulas considered in the previous section--and should, once again, be willing to pay fees to cover administrative costs.

Another way to achieve some trickle down of benefits is through end-user allocations with a forfeiture rule. Firms might be granted permits, say, according to one of the allocation formulas specified in Sec. IV, but with the provision that the firms must forfeit their entitlements if they go out of business.[4] We do not treat this allocation in detail in this section for two reasons: First, in its simplest form, the forfeiture rule would be far less effective than the final product allocation in preventing consumer price increases, plant closures, and worker layoffs--while still imposing some inefficiency losses on the private economy. Second, the simplest form of a forfeiture rule still promises the potential embarrassment of making large wealth transfers to owners of firms that severely cut output and lay off many workers. To avoid this, the forfeiture rule might be modified, say, to require recipient firms to maintain some percentage of baseline output--but then the policy's effects would begin to look more like those of the final product allocation analyzed below.

[4] The forfeited permits would then have to be reintroduced into the market, requiring some administrative mechanism and allocation rule.

ADMINISTRATIVE ISSUES

The final product allocation formula would be more complex and costly to administer than any other allocation considered in this report. Unlike the other allocation policies, this "trickle down" formula requires the annual acquisition and assimilation of data from end-user firms. Although some other allocations also reissue permits annually, they do not require costly acquisition of new data each year.

In addition, several thorny, but not necessarily intractable, administrative questions must be resolved at the policy's outset. The most important of these include defining and measuring the output of each affected industry, devising the actual formula used to convert changes in output levels into changes in permit allocations, and deciding which firms will be eligible for allocations. To a greater degree than most other allocation policies, the regulatory agency would have to devote some resources to resolving important administrative questions prior to promulgating a final product formula.

Determining the qualifying types of output for some industries poses conceptual and practical problems. In some markets, nearly identical final products may be produced with and without CFCs. For example, flexible foam producers manufacture some foam products with CFCs and others with methylene chloride blowing agents, although the latter could be produced with CFCs. Should all the producers' product lines be considered, or only those products currently produced with CFCs? If only product lines currently made with CFCs are included, a definitive specification of the characteristics of qualifying outputs is required so that they can be readily recognized even if no longer made with

CFCs.[5] For at least some product lines, developing such specifications would be administratively difficult and costly.[6] But if all product lines are defined as qualifying, then the allocation will subsidize some product markets that are not harmed by the CFC quota[7]--and, therefore, reduce the compensation available to product markets harmed by the quota. For the purposes of estimating outcomes below, we arbitrarily identify qualifying outputs as those product lines that were manufactured with CFCs in 1980.

A related problem involves defining the appropriate unit for measuring an industry's output when its products are heterogeneous. For example, virtually all CFC-made refrigeration and air conditioning product lines include units of widely varying sizes. Should a chiller with one ton of cooling capacity and a chiller with 1,000 tons of cooling capacity each be defined as one unit of output? For estimation purposes, we assume that the output of such products is measured in terms of cooling capacity.

Perhaps the most sensitive administrative issue would be the formula's treatment of products produced by different industries. This

[5] Note that a qualifying output continues to qualify even if it is no longer made with CFCs. Thus, for example, a particular grade of foam made with CFCs in 1980 would qualify under the allocation formula even if, say, by 1985 it is no longer made with CFCs. In practice, using this rule requires a definitive specification of the characteristics of the qualifying output so that it can be readily recognized even if no longer made with CFCs.

[6] For some industries, such as home refrigeration, the designation of qualifying outputs may pose no serious problems.

[7] An exception is product lines that are converted to non-CFC alternatives in anticipation of coming regulations. If such product lines are excluded from the allocation, their makers will be penalized for their early actions. This possibility raises obvious equity considerations and establishes a questionable precedent for future regulatory actions.

problem is aggravated by the radical differences in the physical characteristics of CFC-made products. For example, how should one million pounds of flexible urethane foam be compared to one million refrigerators? What is required is a set of conversion factors to transform disparate outputs into a common unit of measurement. These conversion factors could then be used to transform each firm's production into "converted" output units; and each firm's share of the permit allocation would equal its share of the total converted output level of all user industries.

In this report, we define the conversion factor for an industry to equal average CFC use (in weighted pounds) per unit of output in 1980, prior to regulation.[8] While there is no compelling reason to prefer this definition over other alternatives, it does have an intuitive interpretation. In effect, these conversion factors reflect the importance of CFCs to production processes during the base year. If a firm produces a product that required a relatively large amount of CFCs per unit of output in 1980, its conversion factor--and, hence, its permit allocation--will be correspondingly higher. In fact, during the first policy year (but not subsequently), these conversion factors lead to the same permit allocation as the historical-base formula analyzed in Sec. IV.

The remaining administrative issue is deciding which firms will be eligible for permit allocations. The primary issue here is whether to

[8] Once specified by reference to 1980 data, the conversion factors remain constant in the allocation formula. A policy-induced change in the amount of CFC used to produce a product does not affect the permit allocation formula.

include firms that enter rapidly growing CFC-related industries (e.g., the foam insulation markets) after the commencement of regulation. Under all the previous allocation policies, participation is restricted to grandfather firms, i.e., those firms in business and using (or selling) CFCs in the base policy year, 1980.[9] Because the mere receipt of permits under the neutral formulas does not alter production costs, this restriction does not place new entrants at a competitive disadvantage. However, the purpose of the final product allocation formula is to enable recipient firms to produce more and charge lower prices under the regulation. Thus, barring new entrants from this "trickle down" formula would place them at a competitive disadvantage.

Our analysis assumes that new entrants are placed on an equal footing with grandfather firms. Thus, if a firm enters a market and seeks to produce a CFC-made product, it would be included in the allocation process. This specification eliminates the potential competitive disadvantages of new entrants and, not coincidentally, maximizes the benefits of the policy for consumers and workers.

To illustrate the implications of these administrative choices, consider a producer of flexible urethane foam. Suppose the firm produces 15 million pounds of foam during a particular policy year, but only two-thirds of this total is considered as qualifying output. In our estimation model, the conversion factor for flexible foam is 0.07 converted output units per pound of foam. Thus, the firm's 10 million

[9] The predicted base formulas discussed in the previous sections are a possible exception. To the extent that growth in a user category is expected to occur through the addition of firms, some permits could be leased temporarily to grandfathers and eventually allocated to new entrants.

pounds of qualifying output translates into 700,000 units of "converted" output. If the total output of all user firms amounts to 400 million converted output units, the firm would receive about 0.2 percent of the total allocation, or 596,750 permits.[10] Now suppose that the firm doubles its output over time, while total converted output grows by only ten percent to 440 million units. Then, the firm would receive about 0.3 percent of the allocation, or over one million permits. Finally, if another firm enters the flexible foam market, it too would qualify for permits through the same process.

OUTCOMES

Our estimates of final product formula outcomes are based on a detailed general equilibrium model of the behavior of user firms under the policy. Because the economics of such "trickle down" policies are fairly complex, a brief summary of the model's implications is a useful prelude to the quantitative results.[11] Even though the first-year allocations under the final product formula are identical to those under the historical-base end-user allocation, over the long run these policies have dramatically different economic effects.

[10] This is computed by the following formula:

$$\frac{\text{conversion factor} \times \text{qualifying output}}{\text{total converted output}} \times \text{total permit allocation} =$$

$$\frac{0.07 \times 10,000,000}{400,000,000} \times 341,000,000 = 596,750.$$

[11] The appendix presents the technical details of the economic model.

The Economic Model

The final product formula distributes wealth to user industries in the form of a per-unit subsidy to production. The subsidy is embodied in the additional permits received by a firm if it increases its relative output level. Consider, for example, our hypothetical flexible foam producer. If he increases his output from 10 to 20 million pounds of foam, the preceding numerical example indicates his permit allocation increases by over 400,000 permits. Each of these permits has a value to the firm determined by the aftermarket equilibrium permit price. Consequently, this incremental change in output generates for the firm not only the profit margin that is the usual reward of the marketplace, but also a subsidy equal to the value of its incremental permit allocation. Because of the final product subsidy, end-user firms are induced to lower product prices (relative to a permit auction) in an attempt to sell more output and obtain a larger permit allocation.

However, the competition by firms for larger permit allocations has another effect, which partially offsets the final product subsidy: it stimulates the demand for permits and, therefore, increases the permit price. Holding other things constant, as firms attempt to increase their outputs, they will demand more CFCs. Of course, "other things" cannot remain constant, because the aggregate limit on CFC use remains. Thus, the increased demand for permits generated by the final product formula means that permit prices must be higher to equilibrate the permit market than under either the auction or neutral allocation policies.

The ultimate effects of this policy depend upon the balance between the final product subsidy (which acts to reduce product prices) and the

higher price of permits (which acts to increase product prices). In the CFC case under consideration, our research concludes that the final product subsidy effect will easily dominate the effect of higher permit prices: Production costs and product prices will be lower than under any of the alternative permit policies.

Quantitative Effects

To summarize the final product allocation's effects, we present results from detailed quantitative analysis for the single policy year, 1985, and discuss departures from the 1985 outcomes that would be experienced in earlier and especially later policy years.

Our quantitative results are best interpreted as a reasonable simulation, rather than precise predictions of the policy's effects. Because we lack information about relevant variables, the simulation results reflect certain assumptions about the allocation formula specification and about consumer responses to higher product prices. If the assumptions were changed, the simulation results would change.

Our assumed conversion factors assure that the policy's per unit subsidy is appreciable for each CFC-user industry. The choice of a radically different set of conversion factors could lead to results quite different from those presented below.

Due to inadequate data on consumer demand, we assume that consumers respond to product prices in only three user categories: TPS foams, flexible foams, and foam insulation. In all other user categories, we assume that the technological responses of firms are the only reaction to the CFC quota--that consumers continue to buy products despite higher

prices. These demand assumptions were originally chosen to assure we would not underestimate the aggregate resource cost of a CFC quota.[12] But, to the extent that we underestimate consumer responsiveness, the quantitative results shown below for the final product allocations contain predictable biases. By underestimating the degree to which consumers adjust their purchases when product prices change, we tend to overstate the amount by which firms must reduce their product prices in order to sell expanded output. If firms can charge higher product prices than we estimate, they will be willing both to pay more for the CFCs they use and to spend more on technologies to control CFC use. In short, because the model probably underestimates consumer price responsiveness, the results shown below probably underestimate the increase in resource costs caused by final product allocations and overestimate the policy-induced reduction in product prices relative to a permit auction.

Though we rely on the CFC demand estimates from Palmer and Quinn (1981), we have reinterpreted the CFC demand schedule for the TPS foams. This demand schedule was originally derived by analyzing the costs to firms of purchasing recovery and recycle equipment or switching to pentane blowing agents, while holding TPS output levels constant. However, because good substitutes exist for many TPS foam applications, the response to regulation in the TPS industry could be dominated by consumers switching to alternative products. For this report, we use the same TPS demand schedule for predicting market outcomes as before. However, we assume that the entire CFC-use reduction in the industry

[12] For further discussion of the consumer response assumptions in our model, see Palmer et al. (1980a), Sec. II.

reflects lower foam output levels due to consumer substitution. While this interpretive change obviously casts some uncertainty over the TPS demand estimates themselves, it is very useful for illustrating the impact of the final product formula on this market, which will likely be hard hit by the permit auction.[13]

On the basis of our analysis, the final product allocation formula is highly effective in achieving its distributive objectives. In 1985, this policy will eliminate about 76 percent of the increase in final product prices that would occur under the permit auction. And this conclusion applies to all user industries.

For consumers, this represents a substantial improvement over the permit auction. By 1985, total transfer payments are about \$321 million under an auction, and the vast majority of these losses are borne by consumers. But, under the final product rule, about 76 percent of these losses to consumers are prevented. Furthermore, to the extent that consumers bear resource costs to reduce their CFC use, these losses too are significantly lessened by the final product formula.

For workers, the benefits of this policy result from the stimulation of output levels (relative to the permit auction) and the prevention of plant closures. Just as the final product formula holds down

[13] The TPS demand schedule, as derived in Palmer et al. (1980a) and revised in Palmer and Quinn (1981), still describes the technical responses of firms at various permit prices, ignoring the effects on final product demand. Essentially, the argument in the text is that consumers will substitute away from polystyrene products before technical options become economically viable for firms. Consequently, the CFC demand schedule used here is too inelastic. However, we do not have the data to measure precisely the responsiveness of consumers, so we use the technical response schedule.

product price increases, it eliminates most of the decline in output and employment levels that would occur under an auction.

As an illustration, consider the policy's effects on the TPS industry. Under the permit auction, the TPS demand schedule indicates that between 1981 and 1985 foam output will decline by over 30 percent. This means that nearly one-third of the workers employed in the industry could lose their jobs during the early years of the policy. In contrast, under the final product formula, estimated TPS output in 1985 is about 8 percent higher than in 1981. Thus, the final product formula eliminates worker layoffs in this industry during the first five policy years. While industry output and employment may decline after 1985 as permit prices rise, these effects will always be less under the final product formula, and the policy will have bought some valuable time during which workers can adjust to the new regulatory environment.

The final product formula also reduces the impact of regulation on workers who are not directly employed by the CFC-related industries. For example, if the TPS industry contracts, suppliers of polystyrene resin and other materials and their employees may suffer losses. Unlike any other allocation policy, the final product formula automatically reduces these losses, to the extent that they occur, by preventing the industry's contraction in the first place.[14]

[14] The targeting under final product allocations is not perfect. To the extent that the formula encourages more technological response than under a permit auction, firms that supply the technological inputs benefit from the final product rule even though they are not losers from a permit auction. At the same time, suppliers of goods and services that are strictly complementary with CFCs are not compensated, even under a final product allocation.

While the final product formula compares favorably on some distributive criteria, these accomplishments are not without cost. In addition to high administrative costs, the policy generates inefficiencies in the permit market and the final product markets.

In the permit market, firms' decisions to acquire permits no longer reflect only the opportunity cost of the permit in alternative uses. Rather, permits are now valuable, in part, because they allow firms to increase output and qualify for larger permit allocations. As a result, the 1985 permit price is driven upward, from \$0.94 under the permit auction to \$1.05 under the final product formula.

As Table 5.1 indicates, higher permit prices result in higher resource costs, though not in all industries. With higher permit prices, CFC-using firms find it economical to use more costly technical options to help control their CFC use. However, the upward pressure on resource cost in all user industries is offset in some of them by the results of consumer behavior. In industries where consumer purchases are sensitive to higher final product prices, the permit auction causes consumers to incur real resource costs in their efforts to avoid consuming CFC-made products. But because the final product allocation does not raise final product prices by as much, consumers do not reduce their purchases by as much, and so the resource costs they bear are lower than under the permit auction. As a result, estimated resource costs are lower in the TPS, foam insulation, and parts of the flexible foam user categories, which account for all the consumer responsiveness in our model.[15]

[15] Table 5.1 does not illustrate this effect for the flexible foam industry, because we have included all flexible foam markets in a single user category.

Table 5.1
RESOURCE COSTS UNDER THE FINAL PRODUCT
ALLOCATION RULE: 1985
(Millions of \$ 1976)

User Category	Resource Costs		
	Permit Auction	Final Product Formula	^a Change
Flexible foam	10.4	13.1	+ 2.7
Solvents	12.3	13.6	+ 1.3
Rigid foam			
TPS	2.7	0.7	- 2.0
Insulation	0.5	0.1	- 0.4
Other	1.9	2.3	+ 0.4
Mobile air conditioning			
Manufacturing	2.6	3.1	+ 0.5
Servicing	0.6	0.7	+ 0.1
Retail food refrigeration	0.9	0.9	-
Chillers	-	-	-
Home refrigeration	-	-	-
Miscellaneous	3.0	3.9	+ 0.9
Total CFC-related	<u>34.7</u>	<u>38.3</u>	<u>+ 3.6</u>
Product market efficiency loss ^b	-	2.0	+ 2.0
Total resource cost ^c	<u>34.7</u>	<u>40.3</u>	<u>+ 5.6</u>

^a Indicates increase (or decrease) of final product formula over the permit auction.

^b Indicates efficiency losses borne by industries other than the CFC-related industries. See text for discussion.

^c Detail may not sum to totals due to rounding.

For the CFC-related industries as a group, resource costs under the final product formula are \$38.3 million, measured in 1976 dollars, an increase of \$3.6 million over the level of the permit auction.

In addition, the final product formula generates inefficiencies in resource allocation between the CFC-related industries as a group and the rest of the economy. Because final product allocations subsidize production, firms in the CFC-related industries expand their output beyond efficient levels. This imposes a cost on the economy, because resources consumed by the regulated product markets would be more highly valued in other industries. As Table 5.1 indicates, we estimate that this additional product market efficiency loss is about \$2.0 million in 1985.

Overall, the final product allocation formula increases the resource cost of achieving the CFC cap to over \$40 million in 1985. In short, under the final product formula, the value of the goods and services the whole economy must sacrifice to achieve the CFC quota is over 16 percent greater in 1985 than under the permit auction.

Transactions costs in the permit aftermarket under the final product formula are similar to the "buck-stops-here" formulas. This is illustrated in Table 5.2, which shows the final product formula's permit allocation and CFC-use pattern and the implied extent of permit trading. The final product formula's 1985 allocation is nearly identical to the previous section's allocation based on predicted baseline CFC use. The reason: Both formulas allocate more permits to rapidly growing

Table 5.2

END-USER PERMIT ALLOCATIONS, CFC USE, AND PERMIT TRADING
UNDER THE FINAL PRODUCT ALLOCATION FORMULA: 1985

User Category	Millions of Permits Allocated ^a	Millions of Weighted Pounds of CFC Used	Millions of Permits	
			Purchased	Sold
Flexible foam	44.1	20.3		23.8
Solvents	61.4	45.5		15.9
Rigid foam				
TPS	10.0	12.9	2.9	
Insulation	83.4	107.6	24.2	
Other	18.7	18.5		0.2
Mobile air conditioning				
Manufacturing	24.6	24.3		0.3
Servicing	43.1	54.2	11.1	
Retail food refrigeration	8.4	5.5		2.9
Chillers	13.3	17.2	3.9	
Home refrigeration	5.0	6.4	1.4	
Miscellaneous	29.1	28.7		0.4
^b Total	341.0	341.0	43.5	43.5

NOTE: The estimated 1985 permit price under the final product formula is \$1.05.

^a

One permit entitles the holder to use one weighted pound of any CFC.

^b

Detail may not sum to totals due to rounding.

industries.[16] As a result, the final product formula's transactions costs will be about the same as under the predicted baseline use formula.

These detailed results characterize the final product formula's effects during 1985, but not other years. The policy's effectiveness will be greater in early policy years, but will erode as time passes. This conclusion reflects the changing balance between the final product formula's subsidy effect and its effect on permit prices.

The policy's subsidy effect will gradually decrease after 1985. The output levels of many CFC-related industries are expected to continue their strong growth even under a CFC cap. As a result, the 341 million permits available for allocation will be steadily spread over a larger converted-output base. Thus, the number of additional permits received by firms for a given expansion in output will gradually decline.

Meanwhile, the difference between the final product formula's permit price and that of a permit auction should become greater, at least through 1990. Our estimation models assume that consumer responsiveness is greater in later policy years, both because regulation's product price effects are greater and because it takes time for buying habits to change.[17] As we noted earlier, greater consumer responsiveness implies bigger permit price effects under the final product formula.

[16] Under the final product formula, permit allocations can increase because of movements along a product demand schedule or because the schedule shifts outward over time. The previous discussion of economic effects focused on the implications of the first economic phenomenon. The increased permit allocations illustrated in Table 5.2 result primarily from the latter.

[17] However, while the relative importance of consumers increases, even in 1990 they account for only about 6 percent of the total CFC-use reduction below baseline levels that occurs in our model.

During the early policy years, these considerations indicate that the final product formula's effectiveness should be greater than in 1985: The policy will eliminate more than 76 percent of the permit auction's increase in product prices. The final product formula's enhanced effectiveness during the early policy years fortuitously occurs at a time when transitional losses, such as those suffered by workers, would otherwise occur in some industries.

Although the final product formula will reduce product prices by decreasing percentages as time goes by, the policy's absolute wealth benefit to consumers will probably still increase, at least through the end of the decade. Suppose, for example, that in 1990 the final product rule reduces consumer price increases (relative to the permit auction) by just 50 percent. Still, the policy would prevent \$478 million in wealth transfers away from consumers in 1990--more than twice as much as in 1985.

Eventually, however, we expect that annual outcomes under the final product formula will converge to the permit auction's outcomes. Given enough time, the final product formula's permit subsidy will be so small that the policy will have no noticeable impact on product prices or, for that matter, on the efficiency of resource use in the private sector. When that date arrives (and it is virtually impossible to predict when it might occur), the only effect of the policy will be the continuation of its potentially large annual administrative costs. Unless some reformulation of the regulation occurs, these annual costs would persist as a dead-weight loss.

EVALUATION

The final product formula epitomizes the difficult regulatory issues addressed in this report. The dilemma posed by this section's analysis is easily summarized. No other allocation policy examined in this report does more to compensate accurately the distributive losses that occur under the permit auction, yet no other policy costs more in achieving its distributive goals.

By 1985, the final product formula adds nearly \$6 million to the annual resource costs required to achieve the CFC quota under the permit auction or the neutral allocation policies. These added costs reflect additional goods and services the whole economy must sacrifice to achieve a given environmental benefit. Moreover, the economy must make further sacrifices because of the high administrative costs required by the annual acquisition of data under the final product formula. Simply stated, under the final product formula, the size of the nation's economic pie will be smaller.

But, these added costs must be considered in the broader context of the policy's overall effects. Even with the private sector's added resource costs, the final product formula is far more efficient than mandatory controls. The added administrative costs are not large when compared to the magnitude of the regulatory losses prevented for the targeted groups. Perhaps most important, no neutral (i.e., efficient) policy can match the final product formula's compensatory effects. To the extent that compensation is a goal of CFC regulation, the policy's inefficiencies are a necessary cost: No policy can do the job cheaper.

And the final product formula's distributive outcomes are noteworthy. This policy relieves the regulatory losses of almost every group in the economy. To a greater extent than any other allocation policy, it achieves the CFC quota--and its consequent environmental benefit--without generating serious harm to any isolated group. The policy partially relieves the regulatory burden of consumers, workers, and others who are not benefited by other allocation formulas. While the owners of user firms are less wealthy than under the "buck-stops-here" formulas, even these firms are compensated by the final product formula: In 1985, the user firms' owners will retain about one-quarter of the proceeds that would otherwise go to the government under the auction. Even the whole economy is better off under the final product formula than in the absence of regulation, so long as the CFC quota's environmental benefits justify the policy's costs.

The targeting of compensation under the final product formula is extremely effective--but not perfect. The allocations will not compensate CFC producers or distributors, groups whose losses due to regulation appear small but are not necessarily zero. The allocations also omit compensation for reduced returns to fixed capital (physical and human) that is strictly complementary to CFC use; the final product rule cannot get around the fact that the CFC quota will restrict CFC use. Meanwhile, some groups that are not harmed by a CFC quota--firms that supply substitute chemicals, for example--can benefit from the increased final product output levels caused by the final product allocations. The final product rule targets compensation relatively well because it

relies on market forces to identify the groups most subject to harm under a permit auction, but even so, some harm will go uncompensated.

Overall, the final product formula offers the best and the worst of the allocation policies we have examined. No policy does better in terms of some of the evaluative criteria developed in Sec. II, and no policy does worse in terms of other criteria. Unfortunately, no amount of analysis can reveal which of these criteria are the more important. Ultimately, whether the final product formula's distributive effects justify its added costs is a judgment that only the policymaker can render.

VI. ALLOCATIONS TO FIRST-LINE BUYERS

By definition, first-line buyers are firms that purchase CFCs directly from the chemical manufacturers.[1] Many CFC distributors and end-user firms are first-line buyers. Because the CFC manufacturers sometimes buy CFCs from one another, they too are first-line firms. On the basis of information from the manufacturers, EPA estimates that there were 4,000 to 5,000 first-line buyers in 1980.

Permit allocations to first-line buyers have been suggested as a way: (a) to prevent the large treasury revenues of a permit auction; (b) to spread transfer payment wealth more broadly than an allocation to the CFC producers; and (c) to avoid some of the administrative costs of an allocation to end users. Feature (a) is not unique to a first-line buyer allocation; all the allocation policies in this report eliminate transfer flows to the U.S. Treasury. As we explain below, whether first-line buyer allocations possess feature (b) depends on how one interprets the concept of a "broader" distribution of wealth. But it does seem clear that a first-line allocation would be among the least costly permit policies to administer, and therefore it deserves detailed consideration.

ALLOCATION FORMULAS

Because low administrative costs are a principal motivation for allocations to first-line buyers, the formula would surely be based on historical data. If firms that have not historically been first-line

[1] Or, presumably, from importers of CFCs in bulk.

buyers could become eligible for permit allocations by newly becoming first-line buyers, the number of permit recipients would soar, thereby driving up administrative costs.[2] And it would require costly new data collection and analysis to try to predict future CFC purchases by first-line buyers rather than base their permit allocations on historical data.

The specific formula considered here would give each first-line firm a number of permits equal to its 1980 weighted purchases of CFCs. Variations on this basic formula are possible. For example, in recognition that there are some random annual fluctuations in firms' purchases, the allocations could be based on each firm's share of total purchases over several years prior to 1981. Though such fine-tuning would affect the welfare of individual firms, it would not influence the overall implications of the formula.

ADMINISTRATIVE ISSUES

The features of this allocation plan make it appear relatively easy to administer. Under the plan, first-line buyers would face strong incentives to identify themselves and document their CFC purchases. Presumably, the CFC manufacturers could verify a firm's first-line buyer status. And, at least by comparison to any of the end-user allocations, the prospective number of permit recipients is small.

[2] If such changes in eligibility were allowed, they would greatly modify the outcomes of a first-line buyer allocation. Existing distribution networks would be seriously disrupted, and the policy would create market inefficiencies.

OUTCOMES

Like other allocations in which permits are granted as full and invariant rights, first-line user allocations would not affect business decisions in the CFC-producing or CFC-using industries. Consumer prices, plant closures, worker layoffs, permit prices, and CFC prices would be the same as under a permit auction.

First-line buyer allocations do produce a very different distribution of transfer payment flows than a permit auction or other allocation policies. Relative to a permit auction, transfers are redirected from the general treasury (taxpayers) to first-line firms. Because they play only a minor role in first-line CFC purchases, the CFC producers would receive far less wealth than under producer allocations. Relative to end-user allocations, some end users would receive more wealth and others would receive less--with many end users receiving none at all. And first-line allocations are the only ones we have studied that would transfer any wealth to CFC distributors.

Some user industry segments possess few (if any) first-line buyers. Only a few of the largest solvent users buy CFCs directly from the manufacturer; a prominent solvent distributor estimates that 80 to 90 percent of solvents pass through distributors. Servicers of refrigeration devices of all kinds typically buy through distributors, and some refrigeration equipment makers act as distributors to service personnel. Thus, although many CFC end users can expect to receive permits even under a first-line buyer allocation, end users in certain industries have little prospect of doing so.

Within a user industry, some firms would receive allocations while others would not. In the Western states, most (if not all) of the CFC-11 used to make flexible and rigid foams is purchased through a distributor--while foamers in other parts of the country are typically first-line buyers. The U.S. automakers all buy CFC directly from the manufacturers for charging mobile air conditioners; but makers of after-market mobile air equipment do not always buy directly. The CFC producers presume that most makers of refrigeration devices (home appliances and chillers) buy CFCs directly from the producers; however, it is unlikely that the producers are aware of the extent to which smaller refrigeration device makers purchase CFCs through distributors. In short, in virtually every industry it is likely that some firms would be among first-line buyers while some of their competitors would not.

Though this circumstance raises the issue of equity, we doubt that it implies any policy effects on industrial structure or competitiveness. The most profitable price to charge for a product, the most cost-effective way to produce it, and the optimal amount to produce are not influenced by the assets a firm can record on its ledger sheet. And a gift of permits in a fixed sum is nothing more than an addition to the firm's assets.[3]

Given the admittedly limited information about the existing CFC distribution network, it appears that 30 to 40 percent of all permits issued would be allocated to distributors. This represents a large

[3] It has been suggested that a firm might refuse to sell permits to a competitor in the hopes of driving him out of business. However, a refrigerator maker does not have to buy permits from another refrigerator maker. He can buy them--for the same market-clearing price--from a firm in any other industry.

transfer of wealth to firms that are expected to face few if any losses from a CFC quota.

EVALUATION

A first-line buyer allocation redirects the flow of transfer payments from the U.S. Treasury to 4,000 to 5,000 firms. The firms include CFC producers, distributors, and selected end users. Because the permits would be allocated as full rights, none of the benefits would be passed through to consumers or workers.

Allocations to first-line users are less expensive to administer than allocations to end users, but more expensive than allocations to the CFC producers. The number of first-line firms directly receiving permits would be much larger than the number of direct recipients under allocations to the CFC producers. However, the CFC producers are publicly held corporations. The direct and indirect "owners" of those corporations number in the hundreds of thousands. Therefore, the number of indirect beneficiaries of permit allocations is very large, even under an allocation to producers. The latter fact raises the question whether the "broader" spread of wealth under the first-line buyer allocations justifies the increase in administrative expense relative to producer allocations.

VII. POLICY TRADE-OFFS

The preceding sections analyze a number of specific permit policy options for a 1980-level CFC quota. The findings are summarized in Table 7.1, which compares the allocation policies with a permit auction. Clearly, a choice among the analyzed allocations requires major trade-offs among resource costs, administrative costs, and distributive consequences.

But what if other allocation formulas are considered? What if the CFC quota were set at different levels? And what would be the nature of the policy choices if a quota with permits were used to control a different environmental hazard? Aside from its specific findings, the present study offers a methodology for answering such questions as well as some general observations about what those answers are likely to be.

In general, policymakers face a basic choice between using neutral and nonneutral allocation formulas. Whatever the policy context--whatever the type of environmental hazard and desired stringency of hazard control--some possible allocation formulas will preserve the resource efficiency of a permit auction while other possible formulas will not.

Neutral policies are easy to identify. They do not vary permit allocations in response to the behavior of recipients. For example, firms can enter or leave a regulated industry, reduce or expand production, or change their production processes without influencing their neutral permit allocations. Consequently, neutral permit allocations do not provide an incentive for behavior that would distort efficient market responses to a quota.

Table 7.1

SUMMARY: COMPARISON OF ALTERNATIVE PERMIT
ALLOCATIONS WITH THE PERMIT AUCTION

Criteria	Neutral Allocations			
	CFC Producers	End Users	First-Line Firms	Final Product Formula
Increase in:				
Resource costs	--	--	--	+16 percent
Administrative costs	Low	High	Medium	High
Wealth Effects for:				
CFC producers	Gain	--	(a)	--
Distributors	--	--	Gain	--
End users	--	Gain	(a)	Gain
Workers	--	--	--	Gain
Consumers	--	--	--	Gain
^b Taxpayers	Loss	Loss	Loss	Loss

NOTE: Tabulation indicates changes in indicated criteria relative to a permit auction. All groups except distributors and taxpayers suffer losses under an auction.

^a

The CFC manufacturers and some end users would also receive some permits under the first-line firms allocation.

^b

Although the permit allocations impose losses on taxpayers relative to an auction, this group would still presumably benefit from CFC regulation due to the environmental benefits of the CFC quota.

By implication, if a regulator plans to use a neutral policy, he can focus attention on its distributive consequences and administrative

costs. Resource costs will not be affected by a neutral allocation. Once the regulator determines who will get permits under a neutral formula, he knows how wealth will be distributed. And the remaining question is how costly it will be to administer the formula.

However, the regulator may find that he cannot adequately compensate regulations' losers using a neutral allocation formula. The individuals most affected by regulation and the levels of their individual losses are difficult to identify. And, as we found in the case of CFCs, the transactions costs associated with allocating permits to such individuals can sometimes outweigh the value of the permits they would receive. For this--or possibly other reasons--the regulator might wish to consider nonneutral allocation formulas.

Nonneutral policies are very difficult to evaluate. Understanding their likely effects depends on good information about the underlying economic forces in a market. In contrast with neutral allocations, nonneutral policies can create benefits (and even costs) for individuals who are not direct recipients of permit allocations. And because nonneutral allocations affect a quota's resource costs as well as administrative costs and wealth distributions, the policymaker has more dimensions of policy evaluation to consider.

Nonneutral formulas can be exceptionally effective at compensating the principal losers from a quota. The reason: The policies can be designed to rely on market forces to identify losers and distribute compensation to them.

But success in using nonneutral formulas for compensation rests on a knife-edge. If the market models on which the formulas are designed

are wrong, or if the formulas are modified only slightly, actual outcomes can differ dramatically from those intended. The formulas might not only fail to compensate losers, but might inflict even greater losses on them--while generating windfall gains for other parties.

Beyond generating these general conclusions about neutral and non-neutral allocations, this study demonstrates how analysis can be used to assess and compare specific allocation formulas. Given appropriate data for the markets to be regulated, models like ours can be used to estimate the market value of permits and determine who will receive that value under alternative formulas. Similarly, the resource cost effects of nonneutral formulas can be assessed using models of market responses. Finally, we found that many of the allocation formula's administrative features can be discerned by simulating the administrative process using estimated data.

But while the methodologies of this study should be applicable to a wide variety of policy contexts, the specific results will not be. A formula's specific outcomes are sensitive to altered regulatory conditions.

Administrative costs are driven largely by the characteristics of the market to be regulated. The CFC market has few producers but very large numbers of end users and a vast array of final products that are ultimately consumed by virtually every member of society. These features generate large differences among permit policies in the potential numbers of permit recipients and in the complexity of permit allocation formulas. Changing the level of the CFC quota would have little effect on the administrative cost comparisons among policy options in

the CFC context. On the other hand, applying a quota with permits in regulatory contexts where only a few, homogeneous firms and a small number of consumers are involved would lead to far smaller differences among the permit policies in their administrative costs.

Regulatory losses that might be compensated vary with the stringency of the quota to be imposed. A far more restrictive CFC quota, for example, would magnify consumer price increases, worker layoffs, and plant closures under a permit auction. Therefore, policies that effectively compensate regulation's losers might look relatively more attractive under a more stringent quota.

Both the resource cost effects and the compensatory effectiveness of a trickle down permit policy derive from a complex set of market relationships. Under the 1980 CFC-level quota, a final product allocation rule effectively compensates regulation's losers by substituting CFC-avoidance actions by firms for product-avoidance actions by consumers. Firms use more technical options for reducing CFC use--and consumers buy more CFC-made products--than under a permit auction. It is this inefficient substitution of one type of action for another that creates the trickle down policy's added resource costs.

If the quota were set at a different level, the feasibility and cost of substituting firms' actions for consumers' actions would be quite different. If the quota were less restrictive, there would be less consumer response to be offset and more low-cost technical options from which to achieve the offset. (Of course, there would also be smaller losses to be compensated.) But if the quota were much more restrictive, there might be very few unexploited technical alternatives

available to offset consumer response. A final product allocation rule would create strong incentives for industry to develop new CFC-saving technologies. But unless and until technological change occurs, the final product allocation rule could do little to benefit consumers under an extremely stringent quota. And if the new technology could not be incorporated by existing firms, their owners and workers would not benefit from the final product allocation rule.

Given the weights he attaches to achieving goals in various policy-evaluation dimensions, a policymaker can use this study's results to choose the optimal permit policy for a 1980 CFC quota. But even if those weights are unchanged, the policy that is judged optimal for the case at hand would not necessarily be optimal under a different CFC quota level or under a quota with permits applied to control a different environmental hazard.

In short, regulatory policymaking poses difficult challenges, both in finding the best way to achieve an aggregate social goal and in finding an acceptable way to distribute cost and benefits. The present study shows how detailed analysis can contribute to evaluation of these difficult choices. The study provides a methodological foundation for evaluating such choices in a wide variety of regulatory contexts. But the study also amply demonstrates that there are no simple rules-of-thumb that will work in all circumstances.

Appendix

AN ECONOMIC MODEL OF THE FINAL
PRODUCT ALLOCATION FORMULA

This appendix presents a general equilibrium model of the behavior of firms under a final product allocation formula. The purpose is threefold:

- o to document the theoretical model used in Sec. V to predict outcomes under a final product formula;
- o to indicate how the policy's economic outcomes are altered when the formula's parameters or the regulatory context are changed;
- o to demonstrate how the theoretical model was used to generate the quantitative estimates in Sec. V.

THE ECONOMIC MODEL

The theoretical model compares the economic effects of two allocation formulas. The first formula is neutral, giving a lump-sum permit grant at a zero price to firms that use (or emit) a regulated pollutant. Each firm's initial allocation represents a complete property right. It can be leased or sold outright, and the amount of the allocation does not vary with the firm's output or shutdown decisions. The second formula allocates permits to user firms at a zero price, on the basis of the firms' shares of final product output levels. Under this final-product-based policy, each firm receives an incomplete property right, since subsequent permit allocations can be reduced depending upon the firm's actions relative to others.

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The model predicts how the final product formula alters economic outcomes relative to a neutral policy. The magnitude and direction of these economic changes depend upon how the final product formula is implemented and the economic characteristics of the regulated industries, including the importance of consumer responsiveness in reducing the pollutant's use and emissions, the market structures of the regulated industries, and their emissions characteristics.

Consider a group of I industries, which all emit a common pollutant that is to be regulated. A representative firm of industry $i \in I$ produces an output q^i at a competitive price p^i , with a consequent emissions level of a^i . [1] The firm's costs are divided into two separable components: Production costs are denoted as $C(q^i)$. The firm can also reduce emissions levels with abatement costs $R(m^i)$, where $m^i = T(q^i) - a^i$ and $R(0) = 0$. Conceptually, $T(q^i)$ can be interpreted as the total pollution load of the firm, which is assumed proportional to output: $T(q^i) = \gamma^i q^i$. [2] Therefore, $m^i = \gamma^i q^i - a^i$ denotes the extent of emissions control or avoidance and $R(m^i)$ the total costs of emissions control.

In the absence of regulation, the firm will undertake no voluntary emissions control, so long as abatement costs are positive. In this case, the firm's emissions are $a^i = \gamma^i q^i$. Thus, the variable γ^i has an

[1] All firms within an industry are assumed identical. Hence, to conserve notation, the industry index is used to denote firm variables as well. Of course, firm characteristics differ across industries.

[2] In the case of CFCs, $T(q^i)$ represents, for example, the total blowing-agent usage by a flexible foamer, a^i indicates the CFC emissions level, and $m^i = T(q^i) - a^i$ indicates the amount of emissions prevented (or the amount of "clean up") due to either recovery-recycle or substitute blowing agents.

intuitive interpretation: It measures the importance of emissions (as measured by the use of a^i per unit of q^i) in the absence of regulation.

Both permit allocation formulas considered in this appendix restrict the aggregate use (or emissions) of the pollutant across all industries to a predetermined level, $A^* = \sum n^i a^i$, where n^i denotes the number of firms in industry i . This is accomplished through the use of economic incentives in the sense that decentralized decisions on where and how to reduce emissions are made by the individual regulated firms, subject only to the aggregate emissions constraint. In each period, a total of A^* permits are issued. Firms receive an initial allocation of permits and an aftermarket is established to facilitate unrestrained exchange of permits. All participants in the aftermarket are price takers and the equilibrium price of a permit is denoted by p^r . The only difference between the policies examined is the initial allocation rule.

The Neutral Allocation Formula

Under the neutral formula, each firm receives a fixed number of permits, $\hat{a}^i$, such that $\sum n^i \hat{a}^i = A^*$. [3] The firm's operating profit plus the value of its allocation is:

$$\Pi^i = p^i q^i - C(q^i) - R(m^i) - p^r (a^i - \hat{a}^i) \quad (1)$$

The profit maximizing firm selects q^i and a^i , such that:

[3] The amount of a firm's allocation depends upon the actual allocation formula chosen by the regulator. For example, in the case of permits allocated to CFC-user firms, $\hat{a}^i$ could be determined by any of the "buck-stops-here" formulas analyzed in Sec. IV.

$$p^i = C_q^i + R_m^i T_q^i \quad (2a)$$

$$p^r = R_m^i \quad (2b)$$

where subscripts denote partial derivatives. Thus, the policy effectively imposes a tax of p^r on emissions. This causes an increase in marginal costs indicated by the last term in Eq. (2a), which is interpreted as the marginal abatement costs of increasing output, q^i , by one unit.

Equation (2b) identifies the firm's "Technical Response Schedule" (TRS). The TRS describes marginal abatement costs as emissions increase, holding final output constant.[4] In effect, the TRS summarizes the cost implications of technical options implemented by firms to reduce pollution levels in response to higher permit prices.

Equilibrium in the final product markets requires that for each industry $i \in I$:

$$\text{Demand} = D(\bar{q}^i) = S(\bar{q}^i) = \text{Supply} \quad (3)$$

where $\bar{q}^i = \sum q^i$ is total industry output.

To facilitate subsequent analysis (without loss of generality), marginal production costs, the TRS, and the industry final product demand schedule are assumed linear. Specifically:

[4] The TRS is conceptually identical to the CFC demand schedules estimated in Palmer et al. (1980a). These demand schedules were derived solely from information on the CFC-saving technical options of firms and assumed that no consumer responses occurred under regulation. Effects on CFC demand due to consumer responses were introduced in Palmer and Quinn (1981).

$$C_q^i = \theta_1^i + \theta_2^i q^i \quad (4a)$$

$$R_m^i = \Omega^i m^i = \Omega^i (\gamma^i q^i - a^i) \quad (4b)$$

$$D(\bar{q}^i) = \alpha_1^i + \alpha_2^i p^i \quad (4c)$$

where the parameters θ_1^i , θ_2^i , Ω^i , $\alpha_1^i > 0$ and $\alpha_2^i < 0$.

From Eqs. (2) to (4), we can easily solve for equilibrium outcomes under the neutral allocation. For the representative firm of industry i:

$$q^i = \frac{p^i - \theta_1^i - p^r \gamma^i}{\theta_2^i} \quad (5a)$$

$$a^i = \gamma^i q^i - \frac{p^r}{\Omega^i} \quad (5b)$$

Equations (5) indicate that for a given product price, p^i , higher permit prices reduce the quantity of a^i demanded and the quantity of q^i supplied. Of course, final product prices will also be affected by regulation. If the price of product i in the absence of regulation is p^{iu} , it can be shown[5] that product prices under a neutral policy (denoted by a superscript h) are:

[5] The derivation of Eq. (6) is straightforward. First, Eq. (5a) is summed over all firms in the industry to derive the industry supply schedule. This is set equal to demand (Eq. (4c)) and the resulting equation solved for p^i . The unregulated product price, p^{iu} , can be derived from a similar equilibrium exercise, assuming $p^r = R_m^i = 0$.

$$p^{ih} = p^{iu} + \psi^i \gamma^i p^r \quad (6)$$

where

$$\psi^i = \frac{\epsilon_S^i}{\epsilon_S^i - \epsilon_D^i} < 1$$

is the elasticity of supply in final product markets divided by the elasticity of supply less the elasticity of demand. Under the neutral policy, the industry supply schedule shifts upward by $\gamma^i p^r$ (the increase in marginal costs due to pollution abatement). Equation (6) indicates the equilibrium product price will then increase according to the well known cost-pass-through index: ψ^i dollars for every \$1 shift in the supply schedule.

Equilibrium in the permit market requires that the "demand for emissions" (as given by Eq. (5b) summed over all firms in all industries) must equal the available supply, A^* . Under a neutral allocation, the equilibrium permit price is:

$$p^{rh} = \frac{A^u - A^*}{\sum \left(\frac{n^i}{\Omega^i} - \psi^i (\gamma^i)^2 \alpha_2^i \right)} = \frac{A^u - A^*}{D^h} \quad (7)$$

where A^u indicates the aggregate unregulated pollution level[6] and D^h is the slope (in absolute value) of the aggregate permit demand schedule under a neutral policy.

[6] That is, $A^u = \sum n^i \gamma^i q^{iu}$ where q^{iu} is the unregulated output of a firm in industry i .

Equation (7) has an intuitive interpretation. The denominator identifies the amount by which the pollution level declines for a \$1 increase in the permit price. Therefore, the equilibrium permit price is the aggregate desired emissions cutback, $A^u - A^*$, divided by this amount.

Equation (7) also shows that an increase in the permit price reduces emissions in two ways. First, the firms in each industry implement emissions-reducing technical responses, indicated by the term n^i / Ω^i . Second, consumers further reduce emissions by switching to other products as prices increase under regulation. This latter effect is summarized by the term $\psi^i (\gamma^i)^2 \alpha_2^i$.

The effects of a neutral policy are interpreted geometrically in Fig. A.1. The bottom panel represents the aggregate permit market, where A^* is the fixed permit supply and $D(A)$ is the permit demand schedule, reflecting both the technical responses of firms and consumer responses to higher prices. In the absence of regulation, the permit price is zero and the aggregate level of pollution is A^u . Under regulation, the price of permits is bid upwards to p^{rh} in the case of a neutral allocation policy. In the upper panel, the effects of regulation in the final product markets are illustrated by an upward shift in the supply schedule (from S^u to S^h) equal to the marginal abatement costs of increasing output, $\gamma^i p^{rh}$. As a result, industry output declines and product prices increase from p^{iu} to p^{ih} .

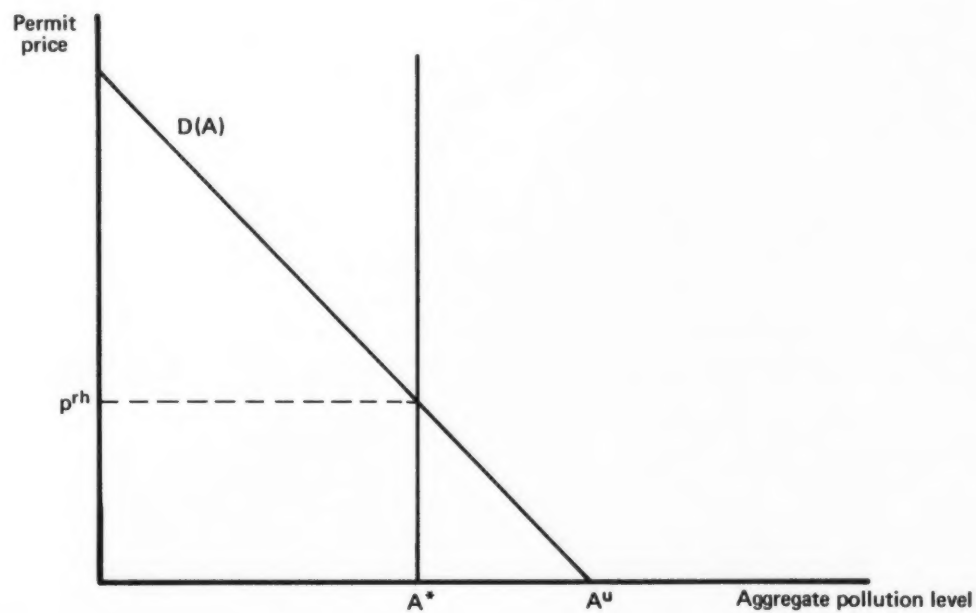
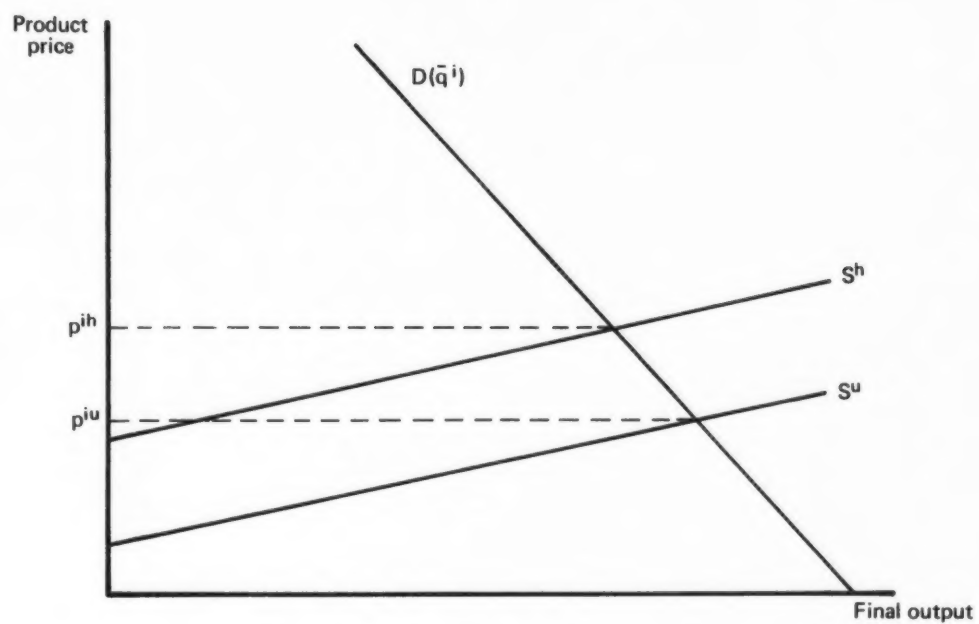


Fig. A.1 — Effects of a neutral allocation formula

The Final Product Formula

Under the final product formula, the permit allocation of a recipient firm is determined by its share of the final product output of all regulated industries. Because the characteristics of different industries' outputs may vary substantially, the final product allocation requires a weighting formula to convert outputs into a common unit of account. Let the conversion factor for industry i be w^i . [7] Therefore, the representative firm in industry i receives an allocation of

$$\frac{w^i a^i}{\sum_n w^n a^n} A^*$$

permits.

The profit function of a firm in industry i under this policy is:

$$\Pi^i = p^i q^i - C(q^i) - R(m^i) - p^r a^i - \left(\frac{w^i a^i}{\sum_n w^n a^n} A^* \right) \quad (8)$$

The firm's first order conditions are:

$$\begin{aligned} p^i &= C_q^i + R_m^i T_q^i - p^r \frac{w^i Q - (w^i)^2 q^i}{Q^2} A^* \\ &= C_q^i + R_m^i T_q^i - p^r \text{SUB}^i \end{aligned} \quad (9a)$$

$$p^r = R_m^i \quad (9b)$$

where Q is total converted output across all industries, $\text{SUB}^i =$

$(w^i/Q)(1 - S^i)A^*$ is the number of additional permits received per unit

[7] In this appendix the conversion factors are completely arbitrary. Following the CFC policy analyzed in Sec. V, one obvious possibility is to let $w^i = \gamma^i$: In effect, each firm's converted production reflects the importance of the pollutant to its production process, as reflected in its unregulated emissions per unit of output. While this formula is examined below, because of the importance of choosing different formulas, we leave the choice open for most of the analysis.

increase in output, and S^i denotes the firm's share of total converted output. Equations (9) demonstrate the tax-subsidy nature of the final product formula. Equation (9b) is identical to Eq. (2b): Like the neutral policy, this policy increases the price of emissions. However, Eq. (9a) indicates that the marginal costs of increasing output are lower under the final product formula, given a particular permit price.

Significantly, the extent of the per-unit subsidy to the firm depends upon its initial share of converted output. When the firm increases output, it dilutes the value of the subsidy for all existing units of output. This is because the same number of permits, A^* , are now being "spread" over a larger total quantity of converted outputs. While the firm will account for this dilution on its own existing output level, it will ignore the external dilution effects borne by other firms. Thus, the total permit subsidy, $p^r \text{SUB}^i$, has two components: $p^r (w^i/Q)A^*$ is the per-unit subsidy value ignoring dilution and the factor $(1 - S^i)$ reflects the extent of internalization by the firm.[8] At one extreme, if there are a large number of relatively small emitters (i.e., $S^i \approx 0$), firms will behave as though the full subsidy applies. At the other extreme, if there is only one regulated firm, it will perceive no subsidy under the final product formula.

[8] As an illustration, suppose that there are a total of 100 permits, that firm A and firm B hold 50 percent and one percent of the initial allocation, respectively, and that $w^i = 1.0$ for all i . Then, if firm A increases output by one unit, its share of the allocation becomes $51/101 = 0.505$, adding 0.5 permits to its allocation. In contrast, if firm B increases output by one unit, its allocation share becomes $2/101 = 0.0198$, adding 0.98 permits to its allocation. Thus, the per-unit value of the subsidy to increased production is nearly twice as much for the smaller firm B.

Just as in the case of a neutral policy, equilibrium under the final product formula requires that $D(q^i) = S(q^i)$ in each product market and that $D(A) = A$ in the permit market. Using the same method as before to solve for equilibrium values, the equilibrium price in industry i under the final product formula is:

$$p^{if} = p^{iu} + \psi^i (p^r \gamma^i - p^r \text{SUB}^i) \quad (10)$$

This expression is exactly analogous to Eq. (6), except that the shift in the supply schedule now reflects the final product subsidy.

From the permit market, the market clearing permit price under the final product formula is:

$$p^{rf} = \frac{A^u - A^*}{\sum \left(\frac{n^i}{\Omega^i} - \psi^i (\gamma^i) \alpha_2^i + \gamma^i \alpha_2^i \psi^i \text{SUB}^i \right)} = \frac{A^u - A^*}{D^f} \quad (11)$$

Equation (11) is the same as Eq. (7), except for the added term in the denominator. This term reflects the necessarily more inelastic demand for emissions under the final product formula (i.e., $D^f < D^h$). This policy induces firms to lower prices and sell more output to consumers (relative to the neutral policy) in an attempt to increase their permit allocation. However, as consumers increase their purchases of final products (relative to a neutral policy), the demand for emissions is stimulated. Consequently, p^{rf} must necessarily be higher than p^{rh} to equilibrate the permit market. And the greater the responsiveness of consumers to lower product prices, the greater will be the permit price increase under the final product formula.

We can now examine the effects of the final product formula on product prices (and, by inference, on output and employment levels). From

Eqs. (6) and (10), the changes in final product prices relative to unregulated levels under these alternative allocations are:

$$\Delta p^{ih} = \psi^i \gamma^i p^{rh}$$

and

$$\Delta p^{if} = \psi^i (\gamma^i p^{rf} - p^{rf} \text{SUB}^i)$$

Thus, the final product formula's price change as a fraction of the change under a neutral policy is:

$$\frac{\Delta p^{if}}{\Delta p^{ih}} = \frac{p^{rf}}{p^{rh}} \left(1 - \frac{\text{SUB}^i}{\gamma^i}\right) = \frac{D^h}{D^f} \left(1 - \frac{\text{SUB}^i}{\gamma^i}\right) \quad (12)$$

This expression describes the conditions under which prices in industry i rise or fall under the final product formula relative to a neutral allocation. The policy effectively lowers prices in industry i (and, therefore, benefits that industry's consumers and workers) whenever the ratio in Eq. (12) is less than unity. In effect, Eq. (12) symbolically summarizes the important balance between the higher permit price (i.e., $p^{rf}/p^{rh} > 1$) and the per-unit subsidy (i.e., $1 - \text{SUB}^i/\gamma^i < 1$), which ultimately determines the final product formula's effectiveness in reducing consumer prices.

Figure A.2 illustrates outcomes under a policy that is effective--i.e., when $\Delta p^{if}/\Delta p^{ih} < 1$. As the discussion of Eq. (11) indicates, the demand for

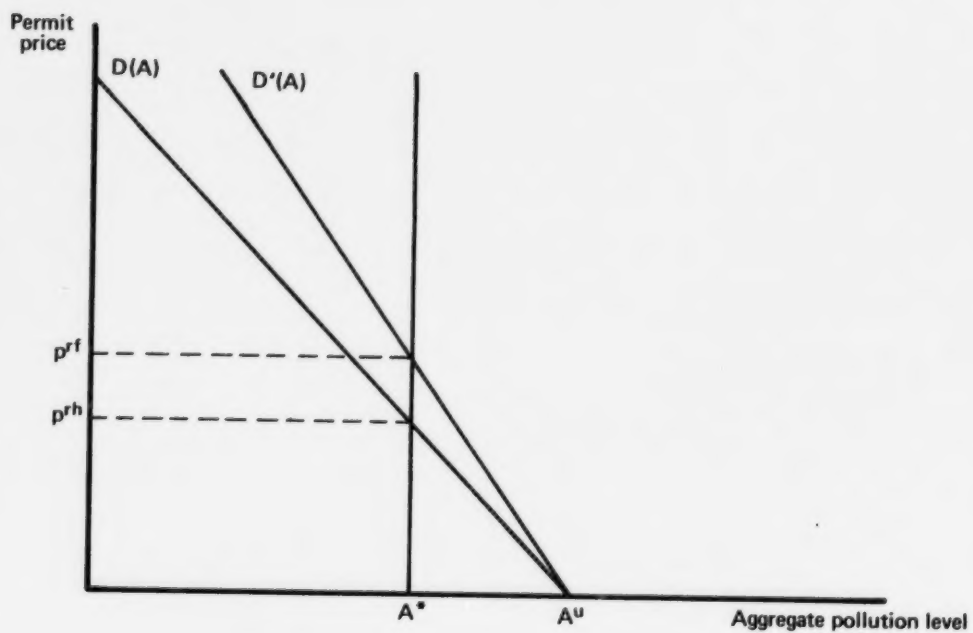
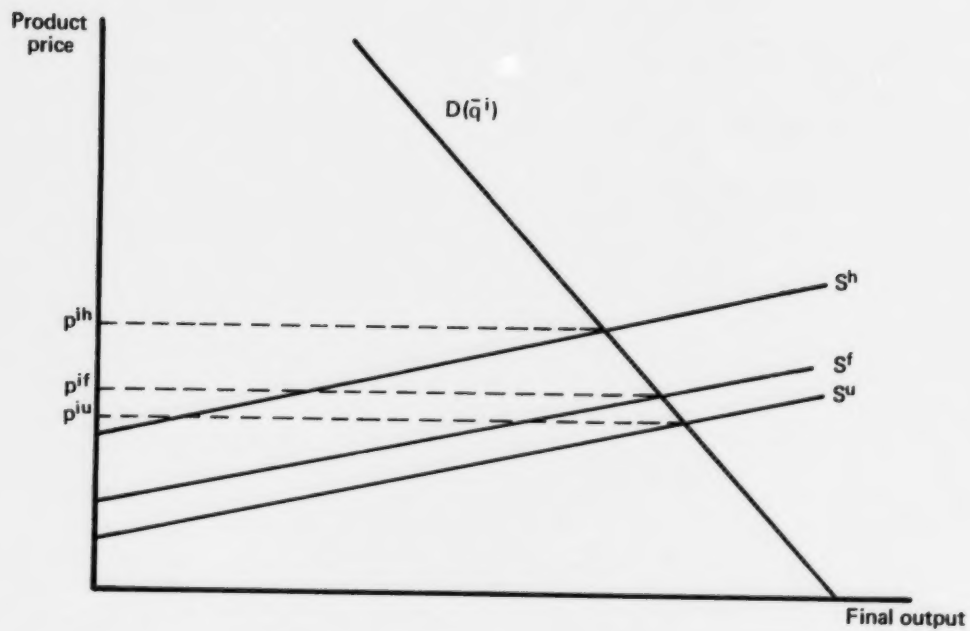


Fig. A.2 — Effects of the final product formula

permits and the permit price increase to $D'(A)$ and p^{rh} , respectively. Despite this higher permit price, however, the per-unit subsidy lowers the regulated supply schedule to S^f , resulting in lower product prices and increased product output and employment.

CFCs: A SPECIAL CASE

In the case of CFC regulation, our quantitative analysis (discussed below) indicates the final product formula is highly effective in mitigating the consumer price increases and final product output and employment decreases that occur under a neutral policy. However, as a close examination of Eq. (12) indicates, this conclusion reflects the particular economic characteristics of the CFC-related industries and the specific conversion factors assumed in Sec. V. Under different circumstances, the final product formula will be less effective and more costly.

The degree of consumer responsiveness is one important factor that may alter the effectiveness of the final product formula. In Eq. (12), the value of the ratio p^{rf}/p^{rh} depends upon the importance of consumer responsiveness as an equilibrating force in the permit market. In the case of CFCs, our quantitative model assumes minimal consumer responsiveness: It accounts for only about six percent of the reduction in CFC use in 1990 under a neutral policy. Even so, while our model generally underestimates consumer responsiveness, under any reasonable scenario the movement of firms along the aggregate TRS will continue to dominate the CFC permit market.[9] In a situation where consumer

[9] The only likely exception is if a far more stringent CFC quota were imposed than the quota analyzed here.

responsiveness is a more significant force, the policy will be less effective. Moreover, higher permit prices lead to higher resource costs, because firms implement additional (more costly) technical options. (See Sec. V.) Consequently, when consumer responsiveness is greater, the final product formula is not only less effective, it is more costly as well.

The final product formula can also have different effects in different markets--and can even result in product price increases in some (but not all) industries. This can be seen by examining the second term in Eq. (12):

$$1 - \frac{SUB^i}{\gamma^i} = 1 - \frac{w^i}{\gamma^i} (1 - S^i) \frac{A^*}{Q}$$

This term can obviously vary across industries, depending, first, upon the value of the regulatory conversion factors (w^i) relative to each industry's dependence on emissions (γ^i) and, second, on the size of firms as measured by their share of total converted output. Generally, the policy will be less effective in industries that are given small conversion factors and are dominated by large firms. In fact, the final product formula can backfire, resulting in cross-subsidization between product markets. Depending upon the set of conversion factors chosen, the policy may reduce product prices in some markets only at the expense of higher product prices in other markets than would occur under a neutral policy.[10]

[10] Such a cross-subsidy can be avoided through the careful choice of conversion factors. For example, suppose we set $w^i = \gamma^i / (1 - S^i)$. Then, $1 - SUB^i / \gamma^i = 1 - A^* / Q$ is the same in all industries. In this case, it can be shown that product prices will fall in all regulated markets, regardless of their economic differences. However, this set of conversion factors biases the allocation towards larger polluters, and thus may not be acceptable on other policy grounds.

In the CFC permit market, these effects do not emerge under the final product formula for two reasons. First, the CFC final product-based policy sets $w^i = \gamma^i$. Therefore, it avoids interindustry discrepancies arising from a divergence between a firm's conversion factor and its dependence on pollution levels as measured by γ^i . Equally important, the CFC allocation policy involves an extremely large number of recipient firms. While converted output levels will vary across user firms, no single firm will account for a significant share of total converted output. For practical purposes, the value of the term $(1 - S^i)$ is unity for all industries in the case of CFCs, and differences in firm size will have no appreciable impact on product price effects in the various user industries.

In other regulatory contexts, these comparisons may be very different. For example, if a regulation were expected to have relatively severe impacts on small firms, conversion factors such that $w^i = \gamma^i$ might be unacceptable. Similarly, the size structures of regulated industries may require that the final product formula be applied with caution. Under different circumstances, the policy can result in added regulatory costs and only slightly reduce--or even exacerbate--the regulatory losses of consumers and workers in some regulated industries.

ESTIMATING OUTCOMES FOR THE CFC FINAL PRODUCT FORMULA

The most critical methodological issue related to quantifying final product formula outcomes is the derivation of the permit demand schedule under the policy. This task is complicated because, while the

theoretical model assumes linear permit demand schedules, the CFC permit demand schedules derived in this research are piecewise linear. However, a comparison of Eqs. (7) and (11) reveals that the slope of each user industry's permit demand schedule changes by an amount equal to $(\gamma^i)^2 \alpha_2^i \psi^i \text{SUB}^i$ relative to the permit auction. Using this theoretical insight and the neutral permit demand schedule employed in Palmer and Quinn (1981), we derived the final product formula permit demand for the single policy year, 1985.

The calculations in the estimation model are simplified considerably by several assumptions. Due to inadequate data, we assume that consumer responsiveness occurs in only three user categories (TPS, flexible foam, and residential foam insulation). In all other user categories, the value of α_2^i is assumed zero. Because of a similar lack of data, we also assign ψ^i the value of unity in all industries, reflecting an assumption of infinitely elastic industry supply.

Thus, the estimation model need adjust permit demand schedules in only three user categories. Moreover, given the above information and the values of $w^i = \gamma^i$ and $S^i \approx 0$ [11], the required adjustment in the slope of permit demand schedules simplifies to $(\gamma^i)^2 \alpha_2^i A^*/Q$. [12] The values of γ^i and α_2^i used in the model are based on information in Palmer et al. (1980a) and Palmer and Quinn (1981). The value of A^* is 341,

[11] Among the consumer responsive industries, the converted output shares of firms are trivial. Even a very large foamer would account for less than one percent of total converted output. Thus, in all cases, the value of $(1 - S^i)$ exceeds 0.99.

[12] Because permit demand schedules measure prices and quantities in weighted pounds, the estimation model must also account for ozone depletion factors. When these are included, the slope change of the demand schedules is actually $(d^i)^2 (\gamma^i)^2 \alpha_2^i A^*/Q$, where d^i is the ozone depletion factor from Table 1.1 for the relevant CFC.

reflecting the CFC quota. The value of Q was estimated using the final demand assumptions in Palmer and Quinn (1981), and in 1985 estimated total converted output is $Q = 434.9$.

Table A.1 illustrates the resulting aggregate demand schedule under the final product formula for permit prices up to the values required to equilibrate the market under the alternative policies. As the table indicates, the equilibrium permit price increases from \$0.94 under a

Table A.1

TWO AGGREGATE CFC DEMAND SCHEDULES: 1985

Permit Price ^a	Aggregate CFC Use (millions of weighted pounds)	
	Neutral Policy	Final Product Formula
\$0.00	442.8	442.8
0.10	413.5	414.1
0.16	406.8	407.8
0.21	402.7	404.0
0.22	401.9	403.3
0.24	399.5	401.0
0.27	396.7	398.4
0.30	391.4	393.3
0.34	384.5	386.7
0.39	379.9	382.5
0.42	378.2	381.0
0.60	361.6	365.9
0.69	355.3	360.3
0.70	354.7	359.8
0.73	353.1	358.5
0.79	350.3	355.9
0.90	343.5	349.5
0.94	341.0	347.3
1.05	334.6	341.0
1.16	328.1	335.2

a

A permit entitles the holder to use one weighted pound of CFC.

neutral policy to \$1.05 under the final product formula.

The resulting effect of the policy on final product prices is determined by Eq. (12). In the special case of CFCs, this equation can be rewritten as:

$$\frac{\Delta P_{ih}^{if}}{\Delta P} = \frac{P_{rh}^{rf}}{P} \left(1 - \frac{A^*}{Q} \right) = \frac{1.05}{0.94} \left(1 - \frac{341.0}{434.9} \right) = 0.24$$

Consequently, the final product formula eliminates about 76 percent of the product price increases that occur under a permit auction or neutral policy in 1985. Given the assumption of linear final product demand, this means that the final product formula will also eliminate about 76 percent of the decline in final product output levels under a neutral policy, with corresponding benefits for workers in the CFC-related industries.

Resource costs in the CFC-user industries are estimated using exactly the same methodology as for a neutral policy in our previous reports. Specifically, resource costs for a user category equal the area under the permit demand schedule. The only differences are that we use the revised permit demand schedules and the final product formula's equilibrium permit price is higher. In industries where we assume no consumer responsiveness occurs, resource costs are higher because firms move up the industry TRS in response to higher permit prices. In consumer-responsive industries, incentives also exist for implementing additional technical responses, but resource costs fall because consumers undertake far fewer CFC-reducing activities.

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